Final Report
Grant No. 12-25-B-1706
Specialty Crops Block Grant Program
Wisconsin Department of Agriculture, Trade and Consumer Protection

Report Date: December 22, 2016

Ben Brancel
Secretary

Wisconsin Department of Agriculture,
Trade and Consumer Protection
2811 Agriculture Drive
Madison, WI 53718
Phone: (608) 224-5015

<u>Contact for Specialty Crop Block Grant Program</u>

Program Coordinator:

Juli Speck
Grant Specialist
Division of Agricultural Development
Phone: (608) 224-5134
Email: juli.speck@wi.gov

INTRODUCTION

The Wisconsin Department of Agriculture received $870,891.70 from the Specialty Crop Block Grant Program, Grant No. 12-25-B-1706. The Department was able to fund 18 projects to promote and improve specialty crops industries in the state of Wisconsin or the Midwest. WI DATCP is using 10% of the funds to cover some administrative costs for the finance department to track and disperse the funding and the Grants Manager to implement the program. Some projects were able to complete their objectives and meet their outcomes without spending all their funds, so an additional project, 13-019 was also funded.

Enclosed are the reports submitted by all 19 grantees.

Grant Projects:

FY13-001	*Minimizing pesticide residues on ginseng root to remove export barriers for Wisconsin growers*
FY13-002	*Deficit irrigation as a means for preserving groundwater resources in Central Wisconsin*
FY13-003	*Developing a clean propagative plant process for Wisconsin hops*
FY13-004	*Pest and disease forecasting for onion and carrot*
FY13-005	*Improving American hazelnut germplasm for growers in the upper Midwest*
FY13-006	*Developing IPM for high tunnel tomatoes*
FY13-007	*Improving fresh market potato varieties*
FY13-008	*Improving food safety practices for fresh market fruit and vegetable producers in Wisconsin*
FY13-009	*Labor efficiency and mechanization to enhance the profitability of Wisconsin fresh market vegetable farms*
FY13-010	*Cranberry flea beetle biology and management*
FY13-011	*Restaurant rewards: growing the wholesale market for fresh fruits and vegetables*
FY13-012	*Evaluating the susceptibility of cold hardy grape varieties to spotted wing drosophila*
FY13-013	*Neonicotinoid use patterns in Central sands*
FY13-014	*Using a novel cover crop blend to increase the sustainability of ornamental plant nursery production*
FY13-015	*GAP/GHP cost share*
FY13-016	*Safe food handling skills for Hmong fresh produce*
FY13-017	*Salad bars in schools go local*
FY13-018	*Increasing the resiliency and stability of Wisconsin fresh fruit and vegetable sales through legal education and legal services*
FY13-019	*Seasonal Extension and Legal Rights Tools for Minority Growers*

1) Minimizing pesticide residues on ginseng root to remove export barriers for Wisconsin growers (FY13-001)

Report Date: March 12, 2015

I. Project Summary

The primary focus of the project was to reduce the overall amount of pesticide residues detected in ginseng by reducing pathogens in the ginseng gardens using seed treatments and organic materials. The project also focused on determining how the number of pesticide applications and their reapplication intervals relate to the residues detected. This goal was to be reached through three objectives: 1.) Partner with industry experts to monitor Maximum Residue Limits (MRLs) among international ginseng markets, 2.) Test seed treatments and biologically active mulch as a means to exclude pests and 3.) Develop pesticide recommendations for growers that protect the crop AND allow it to be exported with minimal or no chemical residues. Prior to the studies outlined in the goals of the proposal, very little was known on which products were a concern for pesticide residues. As a result of this study, three pesticides were identified that when applied to the ginseng crop do not result in detectable residues and include Captan, Sevin, and Quadris (when applied at intervals greater than 7 days). Other pesticides resulted in detectable residues at each sampling and included Brigade. Treatment with Bravo, Quadris, and Endura resulted in residues some of the time and detection was not consistent among the samples. This valuable information provided an opportunity to educate growers regarding a spray plan designed based on likely detectable residues. The extension education meetings and presentations developed to disseminate results from this project were well attended. The grower survey garnered over 70 responses and indicates that pesticide residues are a primary concern among Ginseng growers. Nearly one half of the growers receive information via alerts from the Ginseng Board office. Unfortunately, the compost mulch testing did not identify a material that is effective enough to limit the most series Ginseng pathogens that occur each year.

II. Project Approach

To determine the effectiveness of the organic mulch materials, two greenhouse trials were conducted on the campus of Michigan State University. These trials tested the inclusion of organic mulch materials along with biopesticides into a disease control program against root rot pathogens *Phytophthora cactorum* and *Cylindrocarpon destructans*. For each pathogen, a control soil and fungicide standard were used to compare these experimental control programs.

Seed treatment testing is difficult on Ginseng due to the stratification process and the wide germination rate observed among seed lots. Growers plant their Ginseng gardens in late summer depending on the temperature and soil moisture conditions. To reduce the number of variables associated with seed treatment testing, we conducted the trials directly with two grower cooperators in commercial fields in Marathon County, WI. Joe Heil and Kirk and Kraig Baumann are leaders in the Ginseng industry and are two of the largest growers in the state. Twelve different seed treatments were tested, including an untreated control and a grower

standard. Experimental treatments were tested along with products labeled on other crops. The treated seeds were planted in July (J. Heil) and October (K. Baumann) and plant evaluation will commence once plants emerge in the spring of 2015. This project was discussed at the Growers' August Field Day.

Pesticide residues are a main concern for Wisconsin ginseng growers as residue tolerances can very widely between importing countries. To better understand the relation to certain insecticides/fungicides and their residues, three trials were conducted on grower cooperator ginseng farms. All treatments were applied in accordance to label guidelines with fungicides being reapplied every 7, 14, or 21 days, while insecticides were applied at 14-day intervals. The maximum number of applications allowed per growing season were not exceeded. After the final applications, roots were impartially selected from the replicated beds, washed, dried, and sent to an analytical lab for testing. To offer growers an alternative to products with residue issues, newly registered and experimental fungicides were tested for efficacy against Alternaria blight.

On August 8th 2014, ~80 growers attended the annual Ginseng Research Field Day. The residue trial described in this report was highlighted and growers were able to observe the treated beds first-hand. The results of the organic soil amendment greenhouse trials and residue trials were also presented to growers during this Project's time period and will be reviewed at additional meetings that are scheduled to occur in 2015.

III. Goals and Outcomes Achieved

Goal: Partner with industry to create a customized database with MRLs for the primary international ginseng markets.

A customized MRL database has been developed specifically for Ginseng and is posted on the GBW website. Registered Ginseng growers are able to directly access the database and determine the current status of those pesticides of greatest concern to their exports. The annual Codex Committee on Pesticide Residues (CCPR) meeting was held May 5-10, 2014 in Nanjing, China. The CCPR recommended the ginseng MRLs listed below for approval by the Codex Alimentarius Commission (CAC). The CAC subsequently approved the MRLs in July 2014 and they are now in effect. They will appear in the Codex online pesticide MRL database in the spring, 2015.

New Codex Ginseng MRLs for 2014

- **Fludioxonil:** MRL of 4 ppm set on Ginseng. (US 4 ppm; EU 1 ppm)
- **Pyrimethanil:** MRL of 1.5 ppm set on "Ginseng, dried including red ginseng." (US 1.5 ppm; EU 0.05 ppm)

Fludioxonil is important to the Ginseng industry both as a seed treatment and as a foliar treatment during the field season. Pyrimethanil is labeled for use on Ginseng against *Alternaria* foliar blight and is integrated into many growers' disease management programs.

Goal: Test seed treatments as a means to exclude pests.
A large-scale replicated seed treatment trial was initiated with a grower cooperator in July of 2014. Each treatment was replicated three times with each replication consisting of a 20 ft bed section with a 4 ft buffer between treatments. Treatments were applied to the seeds in accordance to grower standards with a cement mixer immediately prior to planting. Table 1 shows the complete list of treatments and rates. Treatments included a biorational product (Actinovate AG), nutrient-based products (NutriPlant SL and NutriPlant AG), experimental fungicides from both Syngenta and Valent (OXTP, V-10208), ginseng industry disease control standards (Fontelis, Quadris, Captan, and Presidio), and a commonly used seed treatment (Apron MAXX). An insecticide seed treatment (Wrangler) was also included. For a comparison, the growers own seed treatment program was incorporated into the experimental protocol. A second seed treatment trial was treated and planted by a second grower cooperator in October and consist of the same treatments, non-replicated. Starting in May 2015, each replication will be rated for emergence and disease incidence. Ratings will continue until harvest (3 to 4 years).

Stratified and non-stratified seed lots were collected from various growers in 2014 and transported to Michigan State University for testing. *Alternaria alternata*, *A. panax*, *Fusarium* spp., *Penicillium* spp. and *Mucor* sp. were found on all seed stages. A high incidence of *A. panax* (44%) and *A. alternata* (80%) were associated with drupes, as well as, *Fusarium oxysporum* (13%) and *Mucor* spp. (31%). In general, microorganisms on the seed coat of green seed were found at a relatively low frequency in the endosperm. However on stratified seed, occurrences of microorganisms on seed coats were also apparent on endosperms (Fig 4). *Pythium* spp. (40%) were associated only with stratified seed which also had the highest incidence of *Fusarium* spp. (*F. oxysporum*, 33%; *F. solani*, 33%; and *F. avenaceum*, 13%) and *Mucor* sp.

Table 1. Seed Treatment Trial Product List.

Treatment	Company	Active Ingredient	Rate/100 lb seed
Untreated control	--	--	--
Wrangler	Loveland	imidacloprid	5 fl oz
Fontelis SC	DuPont	pethiopyrad	1 fl oz
OXTP SC	Syngenta	oxathiapiprolin	1 fl oz
Presidio SC	Valent	fluopicolide	1 fl oz
V-10208 SC	Valent	ethaboxam	0.6 fl oz
Captan 50W	Drexel	captan	3.3 oz
Apron MAXX	Syngenta	mefenoxam + fludioxonil	5 fl oz
Quadris SC	Syngenta	azoxystrobin	1 fl oz
Nutriplant AG	Amway	various nutrients	6 oz
Nutriplant SL	Amway	various nutrients	4 fl oz
Actinovate AG	Novozymes BioAg	*Streptomyces lydicus*	6 oz

Goal: Test compost and other biorational materials against root rot organisms.
Two trials were initiated in the greenhouse to determine the effectiveness of compost and/or biorational products against root rot pathogens *Cylindrocarpon destructans* and *Phytophthora cactorum*. Each of the compost treatments were mixed 50/50 with a sandy loam soil. For comparison, a sandy loam soil only treatment was also included. The compost treatments, 'La Crosse' and 'Appleton,' were tested alone and in combination with biorational products Tenet (*Trichoderma asperellum*), Serenade Soil (*Bacillus subtilis*), and Actinovate (*Streptomyces*

lydicus). Industry fungicide standards, Fontelis (*Cylindrocarpon*) and Presidio (*Phytophthora*), were also included in each trial.

Results: Cylindrocarpon Trial

Evaluation of organic soil amendments and biopesticides for the control of Cylindrocarpon root rot on ginseng seedlings in the greenhouse, 2014.

Stratified ginseng seeds were mixed in silica sand and stored at 38°F until germination. Germinated seeds were hand planted into 72-cell flats containing sterilized silica sand. Once enough seedlings emerged, they were carefully removed from the sand and observed for any disease symptoms. Any seedlings showing root discoloration were discarded. Three types of soil were used in this trial, a sandy loam soil (autoclaved to reduce weeds and pathogens), or a 50/50 v/v mixture of sandy loam with either 'La Crosse' or 'Appleton' compost. The bare-rooted plants were then transplanted into the soils with eight plants per treatment placed into a completely randomized design. Fungicides were applied as a drench to the uninoculated plants at a volume of 4 fl oz/9 in.^{2} on 27 May. Inoculum was prepared by growing *C. destructans* on potato dextrose agar for 8 weeks. The upper layer of the agar was removed, macerated in water, and diluted to a concentration of 2.9 x 10^7 spores/fl oz. The seedlings were inoculated on 29 May by injecting the 5 ml of conidial solution 1 cm from the base of the stem. A plant health rating (1=no disease symptoms, 2=chlorosis/minor wilting, 3=moderate wilting, 4=severe wilting, 5=plant death) and death (%) were noted on 23 Jun. Due to observed weed pressure in some pots associated with the compost, the number of weeds in each pot were counted on 24 Jun.

Disease pressure in this trial was dependent on the soil type with a varying range of untreated plants dying by the final rating. For all of the soil types, applications of the biopesticides Actinovate, Serenade Soil, and Tenet resulted in plant health ratings statistically equal or worse to the untreated inoculated control (Table 2). Applications of the newly registered fungicide Fontelis was efficacious is controlling Cylindrocarpon root rot with plant death rating lower than the other treatments tested. The 'La Crosse' compost product appeared to have a negative effect on plant health when compared to the other soil types. A possibly explanation for this may be that the composting process was not completed on this product as pots containing the 'La Crosse' compost had various vegetable plants/weeds growing throughout the treatments. Phytotoxicity was not observed on any of the treated plants in this trial.

Table 2. Cylindrocarpon trial results

Soil type, treatment and rate 100/gal	Weeds/pot	Plant health		Plant death (%)	
	24 Jun	23 Jun			
Control Soil					
Untreated uninoculated control	0.0	2.0	a	25.0	abc
Untreated inoculated control	0.0	3.9	b	62.5	cde
Actinovate AG 12 oz	0.0	4.0	b	50.0	bcd
Serenade Soil 6 qt	0.0	3.9	b	62.5	cde
Tenet 2.2 lb	0.0	4.4	b	62.5	cde
Fontelis SC 16 fl oz	0.0	2.0	a	25.0	abc
Appleton Compost					
Untreated inoculated control	0.0	1.5	a	12.5	ab
Actinovate AG 12 oz	0.0	4.8	b	87.5	de
Serenade Soil 6 qt	0.13	4.0	b	75.0	de
Tenet 2.2 lb	0.25	4.5	b	87.5	de
Fontelis SC 16 fl oz	0.0	1.3	a	0.0	a

La Crosse Compost					
Untreated inoculated control	0.75	5.0	b	100.0	e
Actinovate AG 12 oz	0.13	4.5	b	87.5	de
Serenade Soil 6 qt	0.5	4.6	b	87.5	de
Tenet 2.2 lb	0.0	4.3	b	75.0	de
Fontelis SC 16 fl oz	0.13	5.0	b	100.0	e

*Plant health rating is 1 to 5, (1=no disease symptoms, 2=chlorosis/minor wilting, 3=moderate wilting, 4=severe wilting, 5=plant death)
**Column means with a letter in common are not statistically different (LSD; *P*=0.05).

Results: Phytophthora Trial

Evaluation of organic soil amendments and biopesticides for the control of Phytophthora root rot on ginseng seedlings in the greenhouse, 2014.

Stratified ginseng seeds were mixed in silica sand and stored at 38ºF until germination. Germinated seeds were hand planted into 72-cell flats containing sterilized silica sand. Once enough seedlings emerged, they were carefully removed from the sand and observed for any disease symptoms. Any seedlings showing root discoloration were discarded. Three types of soil were used in this trial, a sandy loam soil (autoclaved to reduce weeds and pathogens), or a 50/50 v/v mixture of sandy loam with either 'La Crosse' or 'Appleton' compost. The bare-rooted plants were then transplanted into the soils with eight plants per treatment placed into a completely randomized design. Fungicides were applied as a drench to the uninoculated plants at a volume of 4 fl oz/9 in.^{2} on 27 May. A mefenoxam-resistant isolate of *Phytophthora cactorum* was grown on one quarter-strength V8 agar plates. Flasks filled with two parts millet and one part water were sterilized. Six 1.5-in. plugs of the infested agar were placed into the flasks. The infested millet was allowed to grow for three weeks before being mixed (8 oz/1 ft^3) into a sterilized soilless media on 29 May. A plant health rating (1=no disease symptoms, 2=chlorosis/minor wilting, 3=moderate wilting, 4=severe wilting, 5=plant death) and death (%) were noted 5, 9, 16, and 23 Jun. Due to observed weed pressure in some pots associated with the compost, the number of weeds in each pot were counted on 24 Jun.

Disease pressure was severe in this trial with the untreated inoculated control plants having ≥75% plant death by the final rating, regardless of the soil type (Tables 3 and 4). Due to the difficulty in controlling *Phytophthora cactorum*, no treatment statistically limited infection compared to the untreated inoculated control. Relative to the treatment applied, with the exception of only one treatment, seedlings transplanted into the Appleton compost product had less plant death, versus the sandy loam only seedlings. Actinovate applied to the sandy loam potted seedlings was the only treatment to significantly reduce plant death compared to the untreated control. Weeds were present in the pots containing both compost types. No phytotoxicity was observed on any of the treated plants in this study.

Table 3. Phytophthora trial results

Soil type, treatment and rate 100/gal	Plant death (%)							
	5 Jun		9 Jun	16 Jun		23 Jun	
Control Soil							
Untreated inoculated control	25.0	ab	50.0	100.0	c	100.0	c
Actinovate AG 12 oz	12.5	a	25.0	62.5	abc	62.5	ab
Serenade Soil 6 qt	50.0	ab	50.0	87.5	bc	87.5	bc
Tenet 2.2 lb	50.0	ab	50.0	100.0	c	100.0	c
Presidio SC 4 fl oz	25.0	ab	62.5	100.0	c	100.0	c

Appleton Compost						
Untreated inoculated control	25.0	ab	37.5	75.0	abc	75.0	abc
Actinovate AG 12 oz	12.5	a	25.0	37.5	a	50.0	a
Serenade Soil 6 qt	25.0	ab	25.0	87.5	bc	87.5	bc
Tenet 2.2 lb	25.0	ab	37.5	62.5	abc	75.0	abc
Presidio SC 4 fl oz	25.0	ab	25.0	50.0	ab	87.5	bc
La Crosse Compost							
Untreated inoculated control	25.0	ab	37.5	75.0	abc	75.0	abc
Actinovate AG 12 oz	50.0	ab	50.0	75.0	abc	87.5	bc
Serenade Soil 6 qt	25.0	ab	50.0	100.0	c	100.0	c
Tenet 2.2 lb	12.5	a	50.0	75.0	abc	75.0	abc
Presidio SC 4 fl oz	50.0	ab	50.0	75.0	abc	87.5	bc

*Column means with a letter in common are not statistically different (SNK; *P*=0.05).

Table 4. Phytophthora trial results

Soil type, treatment and rate	Plant health*							Weeds/pot
100/gal	5 Jun	9 Jun		16 Jun		23 Jun		24 Jun
Control Soil								
Untreated inoculated control	3.1	4.4	c	5.0	b	5.0	b	0.0
Actinovate AG 12 oz	2.6	2.9	abc	3.9	ab	4.3	ab	0.0
Serenade Soil 6 qt	3.4	4.0	bc	4.5	b	4.5	ab	0.0
Tenet 2.2 lb	3.8	4.3	c	5.0	b	5.0	b	0.0
Presidio SC 4 fl oz	3.0	4.0	bc	5.0	b	5.0	b	0.0
Appleton Compost								
Untreated inoculated control	2.0	3.1	abc	4.0	b	4.0	ab	0.13
Actinovate AG 12 oz	2.9	2.4	a	2.5	a	3.4	a	0.25
Serenade Soil 6 qt	3.6	3.9	abc	4.5	b	4.9	b	0.13
Tenet 2.2 lb	2.1	3.1	abc	3.8	ab	4.4	ab	0.0
Presidio SC 4 fl oz	2.4	2.6	ab	3.8	ab	4.5	ab	0.0
La Crosse Compost								
Untreated inoculated control	3.9	3.6	abc	4.0	b	4.1	ab	0.5
Actinovate AG 12 oz	3.4	3.3	abc	4.0	b	4.9	b	0.5
Serenade Soil 6 qt	4.1	4.4	c	5.0	b	5.0	b	0.13
Tenet 2.2 lb	3.9	3.6	abc	4.0	b	4.6	b	0.25
Presidio SC 4 fl oz	2.9	3.5	abc	4.4	b	4.5	ab	0.25

*Plant health rating is 1 to 5, (1=no disease symptoms, 2=chlorosis/minor wilting, 3=moderate wilting, 4=severe wilting, 5=plant death)
**Column means with a letter in common are not statistically different (LSD; *P*=0.05).

Project Highlights: The biologically active compost did not contribute to disease suppression or pathogen limitation. In some instances the compost was infested with plants of various weed species and vegetable species.

Goal: Develop pesticide recommendations for growers that protect the crop AND allow it to be exported with minimal chemical residues at harvest.

To determine how pesticide residues accumulate in ginseng roots, three trials were initiated in grower cooperators gardens in 2014. A trial was conducted on a seedling garden, a 2-year-old garden, and a 3-year-old garden. At each location, treatments were replicated four times with each replication consisting of a 20-foot bed length. Treatments were initiated in mid-June and were reapplied at 7-, 14-, or 21-day intervals through August. Insecticide treatments were applied based on grower use patterns. See tables 5-7 for the complete list of treatments. In late

September, roots from a minimum of 3 replications of each treatment were harvested from the 2- and 3-year-old ginseng plots. Due to the small size of the roots, only one replication was harvested from the seedling garden. Roots were cooled for two weeks in accordance to processing standards and were then dried to 70-90% dry matter. After drying was complete, roots were transferred to the Michigan State University Analytical Testing Lab for residue testing. The samples were subsampled and ground with Dichloromethane, Magnesium sulfate, and sodium chloride. It was shaken and poured through a paper filter with sodium sulfate and collected in a round bottom. The sample was roto vap to dryness and brought up in acetonitrile for analysis on either the GC or HPLC coupled to mass spectrometer.

The amount of residue detected in the roots appeared to be related to root age and the active ingredient in question (Tables 5-7). Of the 3-year-old roots tested, nine of the sixteen treatments tested resulted in detectable pesticide residues. Boscalid (Endura) and chlorothalonil (Bravo) were detected in all of the 3-year-old-roots regardless of the application schedule and the total number of applications. The 7-day applications of chlorothalonil to 2-year-old plants resulted in a detected residue higher than any other chlorothalonil treatment. The insecticide chlorpyrifos (Lorsban) was detected in the 3-year-old roots after just one early season application. The insecticide bifenthrin (Bifenture) was detected in all three ages of roots tested. Azoxystrobin was detected in all 2-year-old treated plants and the 7-day applications in the 3-year-old plants. Captan (Captan) and Carbaryl (Sevin XLR and 7G) residues were not detected in any roots in this experiment. The detection of residue from the various products used appeared to be based more on the active ingredient itself and not on the number of applications or reapplication interval. It should be noted that all residues detected in this study were lower than the maximum residue limits set by the U.S. Environmental Protection Agency. Date from these trials will be used to help growers adjust their pest control program and implement products that are less likely to result in pesticide residues.

Efficacy testing was conducted in a separate trial located in the same ginseng garden as the residue testing experiment (Fig 1). Treatments were initiated in late May and reapplied at 7-day intervals throughout the growing season. Treatments were applied with a 4-nozzle boom equipped with 8003VS flat fan nozzles discharged at 40psi and calibrated to deliver 50 gal/acre. With the expectation of the biopesticide Regalia, all treatments limited disease severity to less than half of the untreated control. Treatments included in the residue trial, Bravo Weather Stik, Endura, and Quadris were very efficacious and will continue to be used by growers as standards for blight control. Newly-registered fungicides were included in the experiment as examples of highly effective products that could be used to reduce applications of products associated with residue issues.

Table 5. Residue Trial Results; Seedlings

Treatment/Year	Application Schedule	Active Ingredient	Apps (#)	Average residue detected (ppm)
Endura 70WG 4.5 oz	7-day	boscalid	5	0.0
Endura 70WG 4.5 oz	14-day	boscalid	5	0.0
Endura 70WG 4.5 oz	21-day	boscalid	4	0.0
Bravo Weather Stik SC 2 pt	7-day	chlorothalonil	12	0.0027
Bravo Weather Stik SC 2 pt	14-day	chlorothalonil	6	0.0013
Bravo Weather Stik SC 2 pt	21-day	chlorothalonil	4	0.0013
Captan 80WDG 2.5 lb	7-day	captan	8	0.0

Captan 80WDG 2.5 lb	14-day	captan	6	0.0
Captan 80WDG 2.5 lb	21-day	captan	4	0.0
Quadris SC 15.5 fl oz	7-day	azoxystrobin	8	0.0
Quadris SC 15.5 fl oz	14-day	azoxystrobin	6	0.0
Quadris SC 15.5 fl oz	21-day	azoxystrobin	4	0.0
Lorsban 15G 13.5 lb	1 app/June	chlorpyrifos	1	0.0
Sevin XLR 2 qt	14-day	carbaryl	3	0.0
Sevin 7G 30 lb	14-day	carbaryl	3	0.0
Bifenture EC 6.4 fl oz	14-day	bifenthrin	5	0.0497

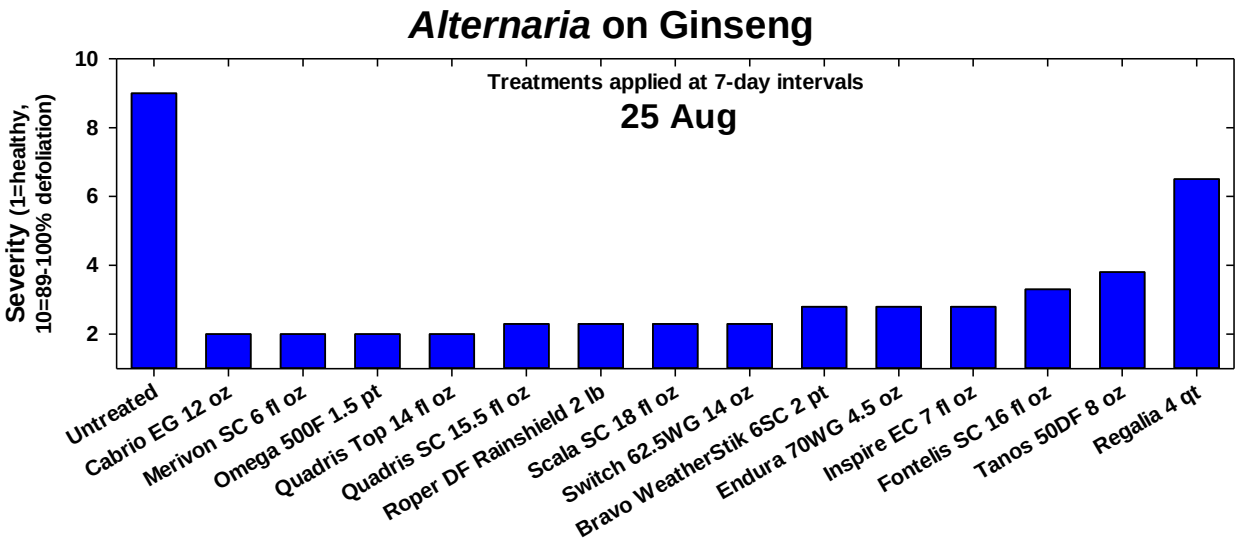
Table 6. Residue Trial Results; 2-Year-Old Ginseng

Treatment/Year	Application Schedule	Active Ingredient	Apps (#)	Average residue detected (ppm)
Endura 70WG 4.5 oz	7-day	boscalid	5	0.0
Endura 70WG 4.5 oz	14-day	boscalid	5	0.056
Endura 70WG 4.5 oz	21-day	boscalid	4	0.11
Bravo Weather Stik SC 2 pt	7-day	chlorothalonil	12	0.306
Bravo Weather Stik SC 2 pt	14-day	chlorothalonil	6	0.0
Bravo Weather Stik SC 2 pt	21-day	chlorothalonil	4	0.0
Captan 80WDG 2.5 lb	7-day	captan	8	0.0
Captan 80WDG 2.5 lb	14-day	captan	6	0.0
Captan 80WDG 2.5 lb	21-day	captan	4	0.0
Quadris SC 15.5 fl oz	7-day	azoxystrobin	8	0.095
Quadris SC 15.5 fl oz	14-day	azoxystrobin	6	0.542
Quadris SC 15.5 fl oz	21-day	azoxystrobin	4	0.041
Lorsban 15G 13.5 lb	1 app/June	chlorpyrifos	1	0.0
Sevin XLR 2 qt	14-day	carbaryl	3	0.0
Sevin 7G 30 lb	14-day	carbaryl	3	0.0
Bifenture EC 6.4 fl oz	14-day	bifenthrin	5	1.27

Table 7. Residue Trial Results; 3-Year-Old Ginseng

Treatment/Year	Application Schedule	Active Ingredient	Apps (#)	Average residue detected (ppm)
Endura 70WG 4.5 oz	7-day	boscalid	5	0.121
Endura 70WG 4.5 oz	14-day	boscalid	5	0.129
Endura 70WG 4.5 oz	21-day	boscalid	4	0.174
Bravo Weather Stik SC 2 pt	7-day	chlorothalonil	8	0.256
Bravo Weather Stik SC 2 pt	14-day	chlorothalonil	6	0.012
Bravo Weather Stik SC 2 pt	21-day	chlorothalonil	4	0.012
Captan 80WDG 2.5 lb	7-day	captan	8	0.0
Captan 80WDG 2.5 lb	14-day	captan	6	0.0
Captan 80WDG 2.5 lb	21-day	captan	4	0.0
Quadris SC 15.5 fl oz	7-day	azoxystrobin	8	0.48
Quadris SC 15.5 fl oz	14-day	azoxystrobin	6	0.0
Quadris SC 15.5 fl oz	21-day	azoxystrobin	4	0.0
Lorsban 15G 13.5 lb	1 app/June	chlorpyrifos	1	0.004
Sevin XLR 2 qt	14-day	carbaryl	3	0.0
Sevin 7G 30 lb	14-day	carbaryl	3	0.0
Bifenture EC 6.4 fl oz	14-day	bifenthrin	5	0.068

Figure 1. Disease severity on Ginseng when select labeled and experimental fungicides were used to limit *Alternaria* blight.



Projects Highlights: Based on the results of this research, several pesticides can be used during the course of the growing season to protect the ginseng foliage and ginseng root without a significant risk of pesticide residue. These include the fungicides Captan 80WDG, Quadris (if used less frequently than a 7-day interval), and the insecticide Sevin (both formulations tested). Other pesticides included in the testing resulted in detectable residues some of the time and included the insecticide Lorsban and the fungicides Endura. Applications of the fungicide Bravo resulted in detectable residues frequently and the insecticide Bifenture resulted in detectable residues each time it was used.

Goal: To disseminate research findings to growers, including Hmong growers, so that they may be incorporated into the growers' production plan in a timely manner.

Project Highlights: On August 8th, over 60 growers, industry representatives, legislators, and researchers attended the 2014 Ginseng Research Field Day. Six Hmong growers (10% of the attendees) were among those who participated. Growers observed various research trials including the plots associated with the FY2013 WI Block Grant. Growers walked among the treatments and discussed the various results of the 2014 experiments with Dr. Mary Hausbeck (Fig 2). Pesticide residues, seed treatments, and biorational products were among the topics covered during the field day.

Research results were presented at the winter ginseng growers' meeting held in Wausau, WI on March 22nd, 2014. Over 130 growers and industry representatives attended the all day meeting and breakout sessions were available for the Hmong grower community (interpreter provided). There were 28 Hmong growers in attendance representing over 20% of the group. Along with research results, growers were given information on currently labeled products and sprayer technologies. Announcements were made twice via the Hmong Community Radio Network in order to reach the Hmong producers. Also, Jeff Lewis who works with Ginseng producers through the Ginseng Herb Co-op provided six announcements to the Hmong Ginseng Grower's

Community regarding pesticide information during the time following the grower meeting in August.

Four GBW Newsletters were distributed to 200 growers during the reporting time period. In addition, disease management recommendations were posted every month from May through September). Email alerts were sent to 55 growers and text alerts were sent to 63 ginseng growers.

Highlights from a survey conducted among the industry are included in Table 8. Results indicate that pesticide residue concerns affect 77% of the respondents. Nearly a quarter of the growers replied that pesticide residues impacted their ability to sell their crop. One half of those surveyed are aware of the disease alerts and other strategies (i.e. Disease Severity Values) that have become available to help time sprays as a means of managing disease and potentially reducing fungicide applications.

Table 8. Survey Results (77 Responses)

1. How many acres of ginseng did you farm in 2013?

<5	5-10	11-25	26-50	51-100	>100
52%	38%	5%	3%	0%	3%

2. Do pesticide residue concerns influence your pest control strategy?:

Yes	No
75%	25%

3.Are there products labeled for ginseng that you do not apply due to residue concerns?:

Yes	No
29%	71%

4.Have pesticides residues impacted your ability to sell your ginseng crop in the past?:

Yes	No
21%	79%

5.Have you sent your ginseng roots to a lab for pesticide residue testing?:

Yes	No
65%	35%

6.Are you aware that Disease Severity Values (DSVs) from two sites in Marathon County are posted twice weekly from May-August on the GBW website?:

Yes	No
51%	49%

7.Have you used the DSVs posted on GBW website as a tool to help manage Alternaria blight?:

Yes	No
48%	52%

8.Are you aware that the GBW website posts a fungicide recommendation calendar?:

Yes	No
77%	23%

9.Have you ever used the disease recommendations calendar posted on the GBW website to guide your control program?:

Yes	No
60%	40%

10.Do you receive 'Disease Alerts' emails from the GBW?:

Yes	No
51%	49%

11.Do you receive 'Disease Alerts' texts from the GBW?:

Yes	No
46%	54%

Figure 2. Dr. Hausbeck discussing experiment results and disease symptoms with growers at the 2014 Ginseng Field Day.

IV. Lessons Learned

Rainfall during the reporting period was unusually high, but we were able to minimize the number of delays in research due to weather. One seed treatment trial was delayed due to the excessive rain.

V. Beneficiaries

The beneficiaries of this project were the Ginseng growers and the associated businesses that are supported, in part, by a thriving and robust Ginseng industry. Rural communities are reliant upon the purchase of goods and services from Ginseng growers. Historically, the profitability of Ginseng had driven the economic success of many small northern communities in Wisconsin. As this industry continues to strengthen and its growers become profitable once again, the supporting communities and commerce will be advantaged. The attendance of Hmong growers at the research meetings during this grant period increased significantly from previous years and could indicate that momentum is building for a meaningful inclusion of this underrepresented group. With the increased prices of the Ginseng root, the successful cultivation of this crop by the Hmong population could significantly increase their profitability. The inclusion of new seed treatments could lessen the number of fungicide applications needed if root pathogen populations can be reduced during the establishment of the garden and the onset of cultivating the crop. The reduction of fungicide applications decreases worker exposure, reduces crop production costs, and increases the potential for increased exports.

VI. Additional Information

Workshops/Tours:

Ginseng Spring Growers' Meeting and Hmong Breakout Session, Wausau, WI Mar 22, 2014 (~120 attendees)

Ginseng Research Field Day, research trials tour at grower-cooperators' farms, Wausau WI, Aug 8, 2014, (~100 attendees).

Presentations:

'Tips and Tricks for Applying Fungicides' B.R. Harlan and M.K. Hausbeck, Ginseng Spring Growers' Meeting and Hmong Breakout Session, Wausau, WI, Mar 2014.

'Plant Clean Seed to Ensure Top Quality and Yield' M.K. Hausbeck and A. Townes, Ginseng Spring Growers' Meeting Hmong Breakout Session, Wausau, WI, Mar 2014.

'Protect Your Crop and Livelihood from Blight and Rot' M.K. Hausbeck, Ginseng Spring Growers' Meeting, Wausau, WI, Mar 2014.

'Ginseng Diseases' M.K. Hausbeck, Ginseng Spring Growers' Meeting Hmong Breakout Session, Wausau, WI, Mar 2014.

'How Weather Influences Alternaria Blight' A. Townes, M.K. Hausbeck, and B.R. Harlan, Ginseng Spring Growers' Meeting, Wausau, WI, Mar 2014.

Other:

Poster: 'Common Diseases of Ginseng' M.K. Hausbeck, B.R Harlan, and S.D. Linderman, 2014.

VII. Contact Info

Anne Buntrock
Ginseng Board Of Wisconsin
668 Maratech Ave., Suite E
Marathon, WI 54448
715-443-2444
ginseng@ginsengboard.com

2) Deficit irrigation as a means for preserving groundwater resources in Central Wisconsin (FY13-002)

Report Date: November 10, 2016

I. Project Summary

Groundwater is a vital natural resource to the State of Wisconsin. The aquifer underlying the Central Sands region of Wisconsin has enabled the development of a multi-billion dollar potato and processing vegetable industry. Multiple factors have started to create concerns about the use of groundwater for irrigation of potato, vegetable, and agronomic crops especially in Central Wisconsin. Central Wisconsin contains one of the largest continuous potato and vegetable production regions in the United States and around the globe. Within a seven county area, irrigated vegetables are produced on 75,000 to 85,000 ha with approximately 48,000 acre potato, 45,000 acre snap bean, 18,000 acre green peas, 55,000 acre of sweet corn, and 6,000 to 11,000 acre of other irrigated vegetables (includes cucumbers, carrots, red beets, and other crops). In addition, there were over 50,000 ha of soybean and corn. The Central Sands are comprised of stratified sand and gravel and are ideal for producing high quality vegetable crops with consistent yield. Consistent production of high quality vegetable crops is the basis for a $6 billion specialty crop industry in Wisconsin (Arledge-Keene and Mitchell, 2011). Irrigation source is groundwater contained in an 80 to 200 foot thick aquifer that resides within 5 to 20 feet below the soil surface across much of the region.

Nearly all of the irrigation water in Central Wisconsin is derived from groundwater. Recently, the impact of irrigation on depth to groundwater has become increasingly scrutinized. In part, this has been triggered by observed declines in surface water levels throughout the region. The Little Plover River dried up during summer of 2006 and 2007 resulting in the death of trout within the stream. Long Lake near Plainfield, WI, has almost completely dried up and other lakes in the region have seen substantial decline in water depth leading to reduced property values for rural residents. Kraft (2009) has estimated that the consumptive water use by irrigated crops of 2 to 6” would result in increased depth to the water table that would correspond to decreased stream flow rates in Little Plover River and other surface water bodies. Consumptive water use is the difference between evapotranspiration and groundwater recharge between field crops and native plant communities (primarily tall grass prairie and pine forest) in the region. Kraft et al. (2012) estimated consumptive water use of 2 to 10” based on observed changes in groundwater depths in monitoring wells in Central Wisconsin relative to wells outside of the region. Furthermore, Kraft estimated groundwater dropped up to 4’ in the most intensively irrigated section of the Central Sands. Kung estimated the Wisconsin River flow has decreased from Tomahawk to Wisconsin Dells (through Central Wisconsin including the irrigated production area of the Central Sands) due to 2” increase in ET (Kung 2011).

Groundwater is a critical resource that must be preserved for long-term viability of the vegetable industry and the local economy. Groundwater is the source for all irrigation and must be preserved for long term sustainability of the vegetable industry. In addition, groundwater serves as the drinking water source for communities and rural residents throughout Central Wisconsin.

Finally, groundwater feeds the streams and lakes in the region. Wisconsin potato and vegetable systems continually evolve to reduce the environmental impacts of crop production.

II. Project Approach

Deficit irrigation has been demonstrated to have little effect on yield and quality of field corn, sweet corn, soybean, and snap bean in Wisconsin and other regions of the world. The primary goal of this project was to evaluate effect of deficit irrigation during vegetative growth on yield and quality of potato, sweet corn, and snap bean. Research was conducted at the UW Hancock Agricultural Research Station over three years (2013-2016) to evaluate the influence of deficit irrigation on yield and quality of potato, sweet corn and garden bean. A randomized complete block with 3 replications was implemented. Each crop, sweet corn, snap bean, and potato were evaluated independently. Within each crop 2 irrigation treatments were used including deficit irrigation and irrigation to meet crop water demand. All crops were managed with current best management practices for all factors except for irrigation.

Irrigation treatments were implemented for the entire growing season and included "normal" irrigation (100% ET) and "deficit" irrigation. The timing of the irrigation treatments were the same but nozzle flow rate in the deficit irrigation plots was 75% of the nozzle flow rate in the normal irrigation plots. Multiple round white potato varieties, russet potato varieties (both fresh market and processing), sweet corn varieties and garden bean varieties were grown under the different irrigation treatments. Potatoes were hand planted to 15 ft rows; round white varieties were planted at 9 inch spacing and russet varieties were planted at 12 inch spacing. There were 2 rows/plot and 4 replicate plots/treatment (irrigation X variety). Both rows were machine harvested and then graded for yield, size distribution and quality. Garden beans were machine planted to 17 ft rows at a seed rate of approximately 170,000 plants/acre. There were 4 rows/plot and 3 replicate plots/treatment. One of the two center rows was machine harvested and graded for yield, size distribution and quality. Sweet corn was machine planted to 17 ft rows at a seed rate of approximately 24,000 plants/acre. There were 4 rows/plot and 3 replicate plots/treatment. One of the two center rows was hand harvested and graded for yield, recovery and quality.

Deficit irrigation consistently reduced yield in round white potato varieties but did not affect size distribution.

Table 1. Influence of deficit irrigation on yield and size distribution of round white chipping varieties at Hancock, WI during 2013.

Treatment		Yield (cwt/acre)		Yield (% total >2 oz)								Specific
Variety	Irrigation	Total	>2 oz	<2 oz	2-4 oz	4-6 oz	6-8 oz	8-10 oz	10-13 oz	13-16 oz	>16 oz	gravity
Lamoka	Normal	381.8	370.5	2.9	12.5	22.1	24.8	22.6	13.3	2.4	2.4	1.084
Lamoka	Deficit (75%)	371.7	353.4	3.5	11.1	22.5	25.5	19.3	12.6	7.3	1.9	1.084
Megachip	Normal	702.3	687.1	1.9	6.8	16.1	22.5	20.9	21.9	8.8	3.1	1.089
Megachip	Deficit (75%)	689.1	666.9	3.3	8.0	17.0	26.0	20.2	20.1	6.7	2.1	1.091
Nicolet	Normal	535.0	512.0	4.0	10.9	18.9	21.7	17.8	17.2	9.4	4.2	1.082
Nicolet	Deficit (75%)	464.9	444.8	3.2	12.7	19.7	20.5	17.8	18.1	7.6	3.9	1.081
Snowden	Normal	784.2	763.5	6.7	19.3	35.2	24.9	11.6	7.7	1.2	0.1	1.087

Snowden	Deficit (75%)	705.4	689.1	7.4	20.0	33.5	24.1	13.6	7.5	1.2	0.2	1.083
LSD (*P*=0.05)		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**3.5**	**NS**	**NS**

Table 2. Influence of deficit irrigation on yield and size distribution of round white chipping varieties at Hancock, WI during 2014.

Treatment		Yield (cwt/acre)		Yield (% total >2 oz)								Specific
Variety	Irrigation	Total	>2 oz	<2 oz	2-4 oz	4-6 oz	6-8 oz	8-10 oz	10-13 oz	13-16 oz	>16 oz	gravity
Lamoka	Normal	692.2	637.7	4.5	9.2	19.8	22.4	18.6	14.8	7.7	7.5	1.090
Lamoka	Deficit (75%)	648.4	606.2	2.6	8.7	25.7	27.4	16.1	12.1	5.4	4.8	1.081
Megachip	Normal	633.7	575.6	1.2	5.1	11.2	18.4	17.9	21.0	14.4	12.2	1.090
Megachip	Deficit (75%)	607.6	571.6	0.3	3.7	8.8	15.6	20.3	22.3	15.9	13.5	1.082
Nicolet	Normal	714.2	691.7	3.1	10.5	19.7	23.0	18.3	14.8	7.5	6.3	1.083
Nicolet	Deficit (75%)	571.0	535.4	1.9	11.2	22.8	21.7	14.9	19.6	4.5	5.5	1.070
Pinnacle	Normal	724.4	689.5	5.7	20.2	28.9	20.9	14.6	8.3	4.2	2.8	1.084
Pinnacle	Deficit (75%)	751.9	715.4	3.3	14.9	24.3	19.5	14.3	13.0	4.6	9.6	1.079
Snowden	Normal	800.1	768.7	2.3	7.5	19.7	23.0	19.8	15.5	7.8	6.8	1.085
Snowden	Deficit (75%)	698.2	671.2	2.5	11.6	25.6	24.2	14.3	10.8	7.3	6.3	1.076
LSD (*P*=0.05)		**84.0**	**87.3**	**NS**	**NS**	**4.4**	**3.6**	**NS**	**4.4**	**NS**	**NS**	**0.003**

Table 3. Influence of deficit irrigation on yield and size distribution of round white chipping varieties at Hancock, WI during 2015.

Treatment		Yield (cwt/acre)		Yield (% total >2 oz)								Specific
Variety	Irrigation	Total	>2 oz	<2 oz	2-4 oz	4-6 oz	6-8 oz	8-10 oz	10-13 oz	13-16 oz	>16 oz	gravity
Lamoka	Normal	488.6	457.8	1.1	14.5	29.0	26.3	14.8	10.6	4.1	0.9	1.083
Lamoka	Deficit (75%)	402.2	390.0	0.9	17.3	29.5	22.0	14.7	9.0	5.0	2.4	1.078
Megachip	Normal	591.7	556.2	0.9	9.9	21.1	21.9	18.0	14.9	7.5	6.8	1.089
Megachip	Deficit (75%)	389.8	368.1	1.4	23.3	27.8	18.7	14.8	7.7	5.1	2.7	1.083
Nicolet	Normal	623.2	596.6	1.8	15.3	25.6	23.4	14.8	11.7	5.1	4.3	1.081
Nicolet	Deficit (75%)	378.0	361.3	2.3	30.8	31.7	20.1	9.1	6.1	1.6	0.8	1.074
Pinnacle	Normal	620.5	586.3	3.1	41.5	32.1	14.3	5.0	5.8	1.3	0.2	1.084
Pinnacle	Deficit (75%)	449.3	425.0	3.9	33.9	31.0	17.3	7.7	6.8	2.6	0.7	1.079
Snowden	Normal	595.4	578.2	1.7	29.8	36.1	17.5	8.8	4.7	2.4	0.7	1.082
Snowden	Deficit (75%)	400.5	389.8	1.8	32.9	34.7	17.4	6.2	6.7	1.7	0.4	1.078
LSD (*P*=0.05)		**NS**	**NS**	**NS**	**NS**	**5.1**	**NS**	**NS**	**NS**	**NS**	**1.9**	**0.003**

NS = Not significant (ANOVA p>0.05)

However, deficit irrigation reduced yield in russet potato varieties only in 2015 and also did not affect size distribution.

Table 4. Influence of deficit irrigation on yield and size distribution of russet potato varieties at Hancock, WI during 2013.

Treatment		Yield (cwt/acre)			Yield (% total >2 oz)							Specific
Variety	Irrigation	Total	>2 oz	<2 oz	2-4 oz	4-6 oz	6-8 oz	8-10 oz	10-13 oz	13-16 oz	>16 oz	gravity
Bannock	Normal	559.9	521.4	5.0	11.6	19.8	20.2	17.3	17.1	7.4	6.6	1.075

Bannock	Deficit (75%)	541.4	506.9	5.6	12.1	19.9	22.2	19.0	18.2	5.5	3.1	1.074
Burbank	Normal	584.6	553.3	4.8	11.0	23.3	23.6	16.3	16.5	6.7	2.6	1.080
Burbank	Deficit (75%)	568.1	545.4	5.9	14.6	24.3	21.1	16.2	12.8	5.7	5.4	1.081
Goldrush	Normal	446.0	414.5	7.3	15.2	21.8	21.5	15.6	15.4	6.6	4.0	1.068
Goldrush	Deficit (75%)	458.3	434.6	5.8	15.4	24.4	22.3	15.4	11.5	6.5	4.5	1.072
Innovator	Normal	455.2	426.2	3.8	9.6	19.1	23.9	13.3	15.7	10.6	7.7	1.071
Innovator	Deficit (75%)	414.1	388.7	2.2	9.9	19.5	22.7	20.6	16.3	7.2	3.9	1.072
Norkotah CO8	Normal	569.7	552.9	3.0	5.7	10.6	17.9	18.1	17.3	15.2	15.4	1.071
Norkotah CO8	Deficit (75%)	521.2	502.7	3.1	9.6	16.7	18.0	18.1	16.8	9.7	11.1	1.069
Silverton	Normal	679.1	659.2	4.1	6.3	14.1	20.3	20.4	21.0	10.4	7.6	1.068
Silverton	Deficit (75%)	561.3	545.6	6.1	10.2	22.1	24.9	20.0	13.8	6.1	3.1	1.066
Umatilla	Normal	612.5	569.2	3.8	10.2	21.0	24.9	16.7	15.9	5.4	6.1	1.082
Umatilla	Deficit (75%)	622.8	591.7	3.0	6.9	17.1	19.9	18.2	18.6	10.1	9.3	1.083
LSD (*P*=0.05)		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 5. Influence of deficit irrigation on yield and size distribution of russet potato varieties at Hancock, WI during 2014.

Treatment		Yield (cwt/acre)			Yield (% total >2 oz)							Specific
Variety	Irrigation	Total	>2 oz	<2 oz	2-4 oz	4-6 oz	6-8 oz	8-10 oz	10-13 oz	13-16 oz	>16 oz	gravity
Bannock	Normal	546.1	487.4	2.4	9.6	17.5	14.7	17.1	17.8	12.5	11.0	1.082
Bannock	Deficit (75%)	592.9	517.3	2.2	6.2	10.5	12.9	18.1	21.1	15.5	15.9	1.077
Burbank	Normal	648.4	573.6	2.0	10.4	21.2	20.1	17.9	18.1	6.9	5.4	1.081
Burbank	Deficit (75%)	641.6	568.8	0.3	6.3	16.0	19.3	14.9	22.1	7.9	13.8	1.075
Goldrush	Normal	643.0	620.4	1.8	7.0	12.5	17.1	16.5	18.5	13.0	15.6	1.071
Goldrush	Deficit (75%)	531.4	505.9	2.0	8.6	11.3	15.7	17.2	19.0	11.4	17.1	1.065
Innovator	Normal	576.8	513.8	0.8	5.5	12.6	11.5	15.7	18.9	13.4	22.5	1.077
Innovator	Deficit (75%)	588.6	528.9	0.9	4.5	10.7	15.0	13.5	18.1	14.7	23.5	1.071
Norkotah CO8	Normal	749.7	723.2	0.3	3.3	8.0	13.7	15.6	21.1	13.3	25.1	1.071
Norkotah CO8	Deficit (75%)	705.2	682.2	0.3	4.2	9.5	11.7	14.5	16.5	13.5	30.3	1.064
Silverton	Normal	553.9	516.2	0.4	4.4	10.1	12.8	13.5	20.7	16.3	22.2	1.067
Silverton	Deficit (75%)	535.9	516.8	1.5	3.5	11.1	17.7	14.3	20.0	13.3	20.4	1.066
Umatilla	Normal	693.7	620.0	1.9	7.9	16.8	21.4	15.6	19.4	10.0	8.9	1.087
Umatilla	Deficit (75%)	715.6	602.1	2.8	10.5	18.3	20.7	18.4	16.0	9.0	7.2	1.080
LSD (*P*=0.05)		**NS**	**NS**	**1.0**	**2.0**	**3.4**	**NS**	**NS**	**3.9**	**NS**	**6.6**	**0.003**

Table 6. Influence of deficit irrigation on yield and size distribution of russet potato varieties at Hancock, WI during 2015.

Treatment		Yield (cwt/acre)			Yield (% total >2 oz)							Specific
Variety	Irrigation	Total	>2 oz	<2 oz	2-4 oz	4-6 oz	6-8 oz	8-10 oz	10-13 oz	13-16 oz	>16 oz	gravity
Bannock	Normal	429.0	389.3	5.5	17.2	19.0	21.3	14.6	15.4	6.9	5.6	1.078
Bannock	Deficit (75%)	379.5	358.2	8.8	20.5	24.1	19.7	15.1	11.3	6.4	3.1	1.071

Burbank	Normal	633.8	570.1	6.7	16.3	27.0	27.3	15.3	9.3	3.7	1.2	1.081
Burbank	Deficit (75%)	389.8	359.9	7.0	32.4	33.7	20.1	6.6	6.4	0.9	0.0	1.075
Goldrush	Normal	495.5	461.9	6.7	21.3	23.7	22.2	13.2	11.9	4.2	3.6	1.072
Goldrush	Deficit (75%)	378.2	358.8	5.7	25.6	32.6	22.4	8.6	8.2	2.5	0.4	1.070
Innovator	Normal	421.9	318.5	3.7	16.0	23.8	16.7	11.0	14.9	7.0	10.7	1.074
Innovator	Deficit (75%)	346.2	308.0	5.5	24.0	25.1	17.9	12.3	13.7	3.3	3.7	1.074
Norkotah CO8	Normal	588.2	564.9	3.6	9.9	22.5	26.8	17.9	12.9	6.7	3.4	1.073
Norkotah CO8	Deficit (75%)	421.9	406.1	4.4	20.0	24.7	21.2	14.2	12.0	4.3	3.8	1.069
Silverton	Normal	566.8	545.8	6.7	12.1	20.2	25.5	17.2	14.5	6.2	4.4	1.068
Silverton	Deficit (75%)	376.3	363.3	5.0	27.9	29.6	20.9	9.1	6.5	4.2	1.9	1.064
Umatilla	Normal	683.5	644.6	5.8	17.9	25.5	25.8	13.3	11.3	4.6	1.7	1.081
Umatilla	Deficit (75%)	422.9	386.3	7.5	33.2	30.7	17.0	10.1	6.8	1.8	0.6	1.074
LSD (*P*=0.05)		**NS**	**104.2**	**NS**	**NS**	**NS**	**4.4**	**NS**	**NS**	**NS**	**4.2**	**0.003**

NS = Not significant (ANOVA p>0.05)

In 2013 and 2015, when yields were not affected by poor stand, deficit irrigation reduced garden bean yield but did not affect size distribution.

Table 7. Influence of deficit irrigation on yield and size distribution of garden bean varieties at Hancock, WI during 2013.

Treatment		Yield			
		Total	Sieve 1-3	Sieve 4 & 5	
Variety	Irrigation	(ton/acre)	(ton/acre)	(ton/acre)	% Total
BA 0999	Normal	5.95	0.50	5.45	91.4
BA 0999	Deficit (75%)	4.49	0.37	4.13	92.0
BA 1001	Normal	6.97	1.65	5.32	76.5
BA 1001	Deficit (75%)	6.02	1.49	4.54	75.3
Caprice	Normal	4.52	1.56	2.95	65.2
Caprice	Deficit (75%)	4.05	1.16	2.87	70.6
DMC 04-88	Normal	8.05	1.82	6.23	77.3
DMC 04-88	Deficit (75%)	5.45	1.06	4.39	80.2
DMC 04-95	Normal	8.18	1.29	6.89	84.2
DMC 04-95	Deficit (75%)	6.42	1.24	5.19	80.6
Huntington	Normal	7.41	2.08	5.31	71.9
Huntington	Deficit (75%)	5.70	0.97	4.73	83.0
SV 1098 GV	Normal	5.95	0.76	5.19	87.2

SV 1098 GV	Deficit (75%)	4.84	0.68	4.18	86.1
Masai	Normal	3.60	3.60	0.00	0.0
Masai	Deficit (75%)	4.13	4.13	0.00	0.0
LSD (*P*=0.05)		**1.21**	**0.52**	**NS**	**5.0**

NS = Not significant (ANOVA p>0.05)

Table 8. Influence of deficit irrigation on yield and size distribution of garden bean varieties at Hancock, WI during 2015.

Treatment		Yield			
Variety	Irrigation	Total (ton/acre)	Sieve 1-3 (ton/acre)	Sieve 4 & 5 (ton/acre)	% Total
Accelerate	Normal	6.98	1.49	5.50	79.2
Accelerate	Deficit (75%)	4.27	0.89	3.38	79.0
BA 0999	Normal	7.50	1.04	6.46	86.2
BA 0999	Deficit (75%)	5.98	0.89	5.09	85.1
BA 1001	Normal	5.48	2.44	3.04	55.0
BA 1001	Deficit (75%)	4.58	1.84	2.73	59.1
Caprice	Normal	5.60	2.39	3.21	57.5
Caprice	Deficit (75%)	4.22	2.17	2.05	48.5
DMC 04-88	Normal	7.69	2.91	4.78	61.9
DMC 04-88	Deficit (75%)	6.70	1.93	4.77	70.6
DMC 04-95	Normal	7.07	2.63	4.44	59.6
DMC 04-95	Deficit (75%)	7.01	1.74	5.26	75.3
Hercules	Normal	5.26	2.05	3.21	60.9
Hercules	Deficit (75%)	4.70	1.90	2.80	58.9
Huntington	Normal	6.92	2.72	4.20	61.0
Huntington	Deficit (75%)	5.64	1.71	3.93	69.8
SV 1098 GV	Normal	5.93	1.78	4.15	69.1
SV 1098 GV	Deficit (75%)	4.70	1.02	3.67	78.2
LSD (*P*=0.05)		**NS**	**NS**	**NS**	**NS**

NS = Not significant (ANOVA p>0.05)

Yield and cut corn recovery in deficit irrigated sweet corn and normal irrigated sweet corn were similar in 2013 and 2014 when target plant populations were achieved.

Table 9. Influence of deficit irrigation on yield of sweet corn varieties at Hancock, WI during 2013.

Treatment		Total yield	Number of	
Variety & Irrigation		(ton/acre)	ears/acre	Lb/ear
DM 21-84	Normal	9.23	25035.13	0.74
DM 21-84	Deficit (75%)	10.03	26629.50	0.76
GH 4927	Normal	8.67	25319.83	0.68
GH 4927	Deficit (75%)	9.83	27312.80	0.72
GSS 1453	Normal	9.00	22434.83	0.81
GSS 1453	Deficit (75%)	10.07	24332.87	0.83

Table 10. Influence of deficit irrigation on yield of sweet corn varieties at Hancock, WI during 2014.

Treatment		Total yield	Number of	
Variety & Irrigation		(ton/acre)	ears/acre	Lb/ear
DM 21-84	Normal	11.70	31432	0.75
DM 21-84	Deficit (75%)	13.10	35531	0.74
GH 4927	Normal	12.87	31432	0.82
GH 4927	Deficit (75%)	14.67	34848	0.86
GSS 1453	Normal	10.50	27332	0.77
GSS 1453	Deficit (75%)	10.23	26990	0.76

GSS 1477	Normal	9.93	24978.20	0.80
GSS 1477	Deficit (75%)	11.00	26743.37	0.84
Overland	Normal	9.00	23023.20	0.78
Overland	Deficit (75%)	9.70	22017.27	0.88
Protege	Normal	8.83	22757.50	0.77
Protege	Deficit (75%)	10.07	26990.13	0.75
Rocker	Normal	8.13	19701.63	0.83
Rocker	Deficit (75%)	9.17	23269.97	0.79
SV 1365	Normal	9.87	22681.57	0.87
SV 1365	Deficit (75%)	9.80	22719.53	0.86
SV 1514 SK	Normal	13.47	26572.53	1.02
SV 1514 SK	Deficit (75%)	12.33	26990.13	0.92
LSD (*P*=0.05)		**NS**	**NS**	**NS**

NS = Not significant (ANOVA p>0.05)

GSS 1477	Normal	12.67	30407	0.83
GSS 1477	Deficit (75%)	12.93	29723	0.88
Overland	Normal	8.73	24257	0.72
Overland	Deficit (75%)	11.57	31090	0.75
Protege	Normal	11.20	28698	0.78
Protege	Deficit (75%)	10.77	28015	0.77
Rocker	Normal	10.67	27332	0.79
Rocker	Deficit (75%)	11.27	27332	0.83
SV 1365	Normal	11.57	29723	0.78
SV 1365	Deficit (75%)	12.60	31090	0.81
SV 1514 SK	Normal	11.10	25965	0.86
SV 1514 SK	Deficit (75%)	14.03	31090	0.91
LSD (*P*=0.05)		**NS**	**NS**	**NS**

NS = Not significant (ANOVA p>0.05)

Table 11. Influence of deficit irrigation on cut corn recovery of sweet corn varieties at Hancock, WI during 2013. (Ten ear sample)

Treatment		Total wt	Hskd wt	Cut Corn	
Variety & Irrigation		(lb)	(lb)	Wt (lb)	% Total
DM 21-84	Normal	6.83	5.00	2.95	42.9
DM 21-84	Deficit (75%)	7.67	5.43	2.83	36.9
GH 4927	Normal	6.73	5.00	2.82	42.1
GH 4927	Deficit (75%)	7.97	6.00	3.24	40.8
GSS 1453	Normal	7.67	5.63	3.10	40.6
GSS 1453	Deficit (75%)	7.87	5.93	3.13	39.9
GSS 1477	Normal	7.80	5.43	3.16	40.6
GSS 1477	Deficit (75%)	7.33	5.47	2.97	40.4
Overland	Normal	7.77	4.77	3.19	41.1
Overland	Deficit (75%)	8.13	5.93	3.44	42.3
Protege	Normal	7.57	5.47	2.99	39.6
Protege	Deficit (75%)	7.13	5.67	3.06	43.1
Rocker	Normal	8.37	5.13	2.87	34.3
Rocker	Deficit (75%)	7.80	5.00	2.42	31.0
SV 1365	Normal	7.77	5.50	3.22	41.7
SV 1365	Deficit (75%)	7.70	5.67	3.18	41.1
SV 1514 SK	Normal	9.23	6.47	3.92	42.5
SV 1514 SK	Deficit (75%)	8.63	6.10	3.58	41.7
LSD (*P*=0.05)		**NS**	**NS**	**NS**	**NS**

Table 12. Influence of deficit irrigation on cut corn recovery of sweet corn varieties at Hancock, WI during 2014. (Ten ear sample)

Treatment		Total wt	Hskd wt	Cut Corn	
Variety & Irrigation		(lb)	(lb)	Wt (lb)	% Total
DM 21-84	Normal	7.97	5.40	3.13	39.3
DM 21-84	Deficit (75%)	8.17	5.35	3.07	37.6
GH 4927	Normal	8.45	5.42	3.67	43.4
GH 4927	Deficit (75%)	8.98	6.42	4.04	44.9
GSS 1453	Normal	7.72	5.18	2.76	35.7
GSS 1453	Deficit (75%)	7.25	5.00	2.87	39.7
GSS 1477	Normal	8.12	5.43	3.42	42.3
GSS 1477	Deficit (75%)	8.96	5.33	3.37	37.9
Overland	Normal	7.37	4.83	2.77	37.6
Overland	Deficit (75%)	7.25	4.87	2.77	38.2
Protege	Normal	8.24	5.59	3.43	41.6
Protege	Deficit (75%)	8.18	5.33	3.39	41.4
Rocker	Normal	7.92	4.76	2.57	32.5
Rocker	Deficit (75%)	8.27	5.02	2.86	34.6
SV 1365	Normal	7.83	5.30	2.99	38.1
SV 1365	Deficit (75%)	7.67	5.12	2.90	37.9
SV 1514 SK	Normal	9.14	5.84	3.55	39.0
SV 1514 SK	Deficit (75%)	9.12	5.50	3.30	36.2
LSD (*P*=0.05)		**NS**	**NS**	**NS**	**NS**

NS = Not significant (ANOVA p>0.05) **NS = Not significant (ANOVA p>0.05)**

III. Goals and Outcomes Achieved

We had conducted preliminary trials with snap bean in cooperation with Del Monte Foods. In those trials, deficit irrigation of 1 to 1.5" resulted in reduced yield of 15 to 20% and no yield impacts in 2010 (left) and 2011 (right), respectively. The difference was that the crop was in the bloom or reproductive stage during irrigation deficit in 2010 and was in the vegetative stage of growth during deficit irrigation in 2011. Deficit irrigation of 1.5" cm would reduce pumping by approximately 5.6 million gallons on quarter section pivot of snap beans.

In addition to small plot trials with snap bean, we have also conducted field scale demonstration trials in cooperation with Coloma Farms. In these demonstrations, deficit irrigation during vegetative phase of field corn resulted in application of 1.5 to 3" less water than maintaining irrigation equal to ET. In soybean, deficit irrigation reduced application of water by 3 or more inches to the field. Potential ET, total water applied (irrigation + precipitation), irrigation and precipitation are plotted. Potential ET for the summer was almost 55 cm, while total water applied was 35 cm. Yield monitoring of deficit versus maintenance irrigation resulted in no observed yield loss across either crop with reduction in irrigation pumping of 5 to 10 million gallons on quarter section irrigation pivots.

Varietal selection will play a role in utilization of deficit irrigation strategies. Results from 2015 show that, in general, across varieties rooting depths of deficit irrigated sweet corn tend to be deeper than their fully irrigated counterparts. More investigation of rooting depth by variety within each major crop could provide insight allowing for producers to choose deeper rooted selections which could improve yields while reducing water consumption

Hancock 2015 - Root Zone Depth from Aquaspy Data

	Sweet Corn Deficit	Sweet Corn Full	Potato Deficit	Potato Full
Date	Active Root Zone Depth (in)	Active Root Zone Depth (in)	Active Root Zone Depth (in)	Active Root Zone Depth (in)
25-Jun	6-8	8-12	16-20	16-20
9-Jul	8-12	8-12	20-24	20-24
23-Jul	12-14	12-16	20-24	20-24
6-Aug	16-24	12-16	20-24	20-24
20-Aug	18-24	16-20	20-24	20-24
31-Aug	18-24	16-20	20-24	20-24
Probe Removed	31-Aug	31-Aug	1-Sep	1-Sep

IV. Lessons Learned

It may be possible to calculate a variety's water use efficiency based on marketable, estimated crop value and total yield per gallon of water. Cost benefit analysis relating irrigation input to yield also may be useful when considering how often and how much to irrigate. Improvements in

yield and potato value per irrigation inch and per kWatt of electricity could enable to producers maximize production while minimizing environmental impacts. Although it varies widely on an annual basis, a 5 lb bag of fresh market potatoes is currently estimated to use approximately 3 gallons of water per irrigation inch. Improvement of just 5 to 10 % could result in real benefit for producers and communities.

V. Beneficiaries

Vegetable Growers have obvious benefit through improved production efficiency, which could allow for similar production at reduced cost. This includes 140 potato growers and 1500 fresh market vegetable growers. Production practices that preserve groundwater quantity and quality assist in meeting sustainability goals for marketing and help insure future of vegetable industry in Central Wisconsin.

Residents of Central Wisconsin benefit from reduced groundwater pumping and reduced nutrient and pesticide losses to groundwater and a corresponding reduction in potential for contamination. Preservation of water resources could improve groundwater quality and depths, lake levels, stream flows and land values.

VI. Additional Information

None

VII. Contact Info

Russ Groves
Professor of Entomology
University of Wisconsin - Madison
537 Russell Laboratories
1630 Linden Dr
Madison, WI 53706
(608) 262-3229
groves@entomology.wisc.edu

3) Developing a clean propagative plant process for Wisconsin hops (FY13-003)

Report Date: November 10, 2016

I. Project Summary

We established a production system for pathogen-free hop rhizomes, initiated variety trialing to identify hop varieties adapted to produce high yields of excellent quality hop cones under Wisconsin conditions, evaluated health of existing Wisconsin hop yards, and coordinated educational opportunities with UWEX to disseminate our findings.

Hops are a labor intensive, perennial flavor crop that is typically harvested in late summer to fall of each year after yard establishment. Hops production has grown significantly in Wisconsin over the last 5 years with over 50 producers raising one half acre or more. Over a century ago, hops production in Sauk County Wisconsin comprised 20% of world production. In the late 1800's production declined in the state due, in part, to disease limitations. Currently, Wisconsin hops growers have, by necessity, relied upon out-of-state sources of hops rhizomes that are not verified for pathogen-free status. As the seat of the U.S. hops industry is in the Pacific Northwest, predominant available cultivars are not necessarily best suited for the unique environmental conditions of Wisconsin or its unique craft brewing industry. The availability and establishment of pathogen-free propagative plant material promotes field production with optimum yield, quality, and environmental and economic sustainability. Further, the development of a sustainable method of rhizome production in Wisconsin for Wisconsin will limit introduction of hops pathogens and create a mechanism for further advances in identifying cultivars with regionally specific traits of interest. Demand for high quality Wisconsin-grown hops has increased with the expansion of craft beer/beverage production. With collaboration from UW Extension, UW-Plant Pathology, growers, allied processing industries, and guidance from the WI Seed Potato Certification Program, we completed our above outlined project objectives. This project directly supported the growth of the Wisconsin hop industry.

B. This FY2013 DATCP SCBG was not previously funded with the SCBG program. The project complimented work previously funded by a North Central regional SARE (Sustainable Agriculture Research and Education) project.

II. Project Approach

I listed our project tasks, approaches, and results, below, in order of our previously stated objectives.

Objective 1: We established a pathogen-free tissue culture collection of hop varieties, and produced pathogen-free planting material for on-farm variety evaluations. In addition clean varieties were shared on an ad-hoc basis for the establishment of clean, new hop yards for commercial production.

A pathogen-free tissue culture collection is the starting point for generating planting material for variety evaluation, and for providing pathogen-free planting stock for Wisconsin hop growers. Pathogen-free hop varieties are available as tissue culture plantlets or cuttings from the Clean Plant Center of the Northwest (CPCNW) at Washington State University, and from the National Clonal Germplasm Repository (NCGR) in Corvallis, OR. Protocols specific to hop tissue culture maintenance have been obtained from the CPCNW and NCGR. NCGR lists 185 hop cultivars and selections in its collection, including 14 of the 21 hop varieties recently planted by Wisconsin growers. Since only small amounts of plant material are available from these two sources, we established a clonal collection at UW-Madison in order to produce sufficient quantities of pathogen-free planting material for participatory hop variety trialing by Wisconsin hop growers. Varieties for on-farm evaluation were chosen in collaboration with participating hop growers and the grower advisory board.

To produce planting material for variety evaluations, we transferred tissue culture plantlets to sterilized potting medium in greenhouse conditions. Once these plants were large enough, softwood cuttings were taken and rooted in a misting chamber before being transferred to sterilized potting medium. These plants were then hardened off in coldframes before planting in hop yards of participating growers.

We generated cultivar quality data across the process of tissue culture, plantlet and field production (Objective 2). Summaries of these data are being shared on an ad hoc basis with interested growers. A formal extension publication is in development for more broadly sharing results of this objective. Publication is ongoing at time of this final report (inclusion of some results in UWEX A3422 Commercial Vegetable Production Guide).

Objective 2: We evaluated hop rhizome production methods to optimize productivity and economic sustainability. In particular, two methods were compared for production of nuclear and propagation stock. We defined nuclear stock as plants derived from tissue culture plantlets that were maintained in greenhouse conditions and used for further propagation, and propagation stock as plants derived from nuclear stock and made available to hop growers for variety evaluation and further propagation. For method 1, the standard approach, tissue culture plantlets were transferred to sterilized potting medium and grown in a greenhouse (nuclear stock). Softwood cuttings were taken from these plants and rooted in a misting chamber before being transferred to sterilized potting medium (propagation stock). For method 2, tissue culture plantlets were transferred to a nutrient film technology (NFT) system in a greenhouse (nuclear stock). Since NFT systems allow access to parts of the plant normally covered by soil, we hypothesized that it would be possible to take both softwood cuttings and rhizome cuttings from these plants. The two methods were compared for plant growth and cutting production, and inputs of time and materials were tracked to determine the most efficient production methods.

Objective 3: We coordinated participatory variety trials in Wisconsin hop yards, and evaluated disease incidence in existing plantings. Field variety trials on grower cooperator farms were conducted to evaluate agronomic traits of 10 cultivars selected by industry. Grower cooperators (Albers, Buss, Urness, Gorst Valley) included 10 plants of each cultivar in standard production in their hop yards. Cooperator farms represented key hop production areas in the state of Wisconsin to best evaluate cultivars under a range of state soils and climates. In year 1, growers

were provided with an evaluation form prompting them for observations of rhizome establishment, growth status, vigor, health, and pathogen/pest status. Staff from the Gevens program at the UW-Madison routinely scouted and evaluated the trial cultivars at each commercial location, in addition to the grower cooperator observation. This standardization of observations enabled us to uniformly assess cultivar status as observed by growers and Geven program staff. Data were subjected to appropriate analyses and a summary report was provided to cooperating producers and industry at large through UWEX publication and the UWEX Vegetable Crop Updates newsletter, as well as at grower education conferences during 2014-2016.

Objective 4: We educated and informed current and future WI hop growers about variety selection for the WI growing environment and craft brewing industry, and the importance of disease-free planting stocks for healthy hop yards. UWEX, through lead efforts of Carl Duley and former Vernon County agent, Tim Rehbein, had established positive rapport with hops growers. A March 2013 UWEX Hops Production Meeting, held in the Wisconsin Dells, drew a crowd of over 100 comprised of both established and new growers, craft and hobby brewers, and several representatives of hops cooperatives and exchanges. Respondents to the program survey indicated that all components of the education program were successful in raising the level of awareness of production practices from a low-moderate status pre-meeting to moderate-high post-meeting. The meeting stimulated much discussion and interest in a Wisconsin-specific clean hops rhizome program, with multiple respondents citing the development of this program as a priority for industry advancement. Subsequent annual hops meetings, held each March, drew crowds of between 100 to 200 growers of varying production knowledge bases.

The venue for workshops varied with a fall workshop held in a grower's hop yard in a 'field walk' approach to discussing the system in breadth. And, a winter educational workshop provided greater depth to particular areas of interest and promote discussion of longer term vision for hops.

III. Goals and Outcomes Achieved

A. Our project addressed several of the 2013 Funding Priorities of the Wisconsin Specialty Crop Block Grant Program. We increased the availability of disease-free rhizomes, and selected varieties that have genetic resistance to pests and diseases, improving pest and disease control in Wisconsin hop yards. Hop varieties selected for pest and disease resistance, and for agronomic performance in Wisconsin conditions, have, in general, required fewer inputs and were, thus, more environmentally sustainable. Our educational efforts in each of the project years has established a regular demand for continued, progressive, sessions to hop growers (novice to experienced) from within Wisconsin and from surrounding states. Our programming has led to partnerships with other states' land extension programming as well as with the Great Lakes Hops Working Group funded by the north central Integrated Pest Management resource.

Products of this project included:

EXTENSION PUBLICATIONS
Single Print Extension Bulletins

1. **Gevens, A.J**., Marks, M.E. 2014. *Hop Downy Mildew: Identification and Management*. UW-Extension Publication.

4. **Gevens, A.J**., Marks, M.E. 2014. *Hop Powdery Mildew: Identification and Management*. UW-Extension Publication.

2. **Gevens, A.J**., Marks, M.E. 2014. *Hop Viruses: Identification and Management*. UW-Extension Publication.

Trade Journal Publications

1. **Marks, M.E.,** Gevens, A.J. 2015. What's hoppin' in Wisconsin hops?! Fresh. A magazine of the Wisconsin Fresh Market Fruit and Vegetable Growers Association (April Edition).

Newsletter Articles

1. **Gevens, A.J.** 2016. Vegetable disease update: DSV (Blitecast, Late Blight) and P-Day (Early Blight) updates, late blight and cucurbit downy mildew national updates, powdery mildew on hops, diagnostic updates. *Wisconsin Crop Manager*, Vegetable Crop Updates #23. August 12.

2. **Gevens, A.J.** 2016. Vegetable disease updates: DSV (Blitecast, Late Blight) and P-Day (Early Blight) updates, early season late blight symptoms and inoculum sources; management link to potato blackleg seminar from Focus on Potato, WI hop updates. *Wisconsin Crop Manager*, Vegetable Crop Updates #9. May 27.

3. **Gevens, A.J.** 2016. Vegetable disease updates: national late blight updates, hop downy mildew updates for Wisconsin. *Wisconsin Crop Manager*, Vegetable Crop Updates #5. April 29.

4. **Gevens, A.J.** 2015. Potato fungicide updates for 2015: new registrations and label updates. Hop disease identification and management. *Wisconsin Crop Manager*, Vegetable Crop Update #2. April 3.

5. **Gevens, A.J.** 2014. Vegetable disease update: Potato production updates, Late Blight Updates, Blitecast and P-Days for late blight and early blight management, Cucurbit downy mildew update, Hops update. *Wisconsin Crop Manager*, Vegetable Crop Update #13. July 11.

6. **Gevens, A.J.** 2014. Vegetable disease update: Late blight reminders, updates, and a look at Blitecast, Hop downy mildew detected in Portage and Dane Counties, Cucurbit downy mildew -- info resources. *Wisconsin Crop Manager*, Vegetable Crop Update #6. May 23, 2014. (Spanish Version Available)

7. **Gevens, A.J.** 2014. Vegetable disease update: Early Season Hop Update, Considerations for organic late blight control. *Wisconsin Crop Manager*, Vegetable Crop Update #3. April 28, 2014. Spanish Version Available Online.

8. **Gevens, A.J.** 2013. Vegetable disease update: early season damping-off and hop downy mildew. *Wisconsin Crop Manager*, Vegetable Crop Update #4. May 11, 2013.

Local and State Presentations

	Date	***Presentation title,* event, and location**
	2016	
1.	Jul 8	***Hop Disease Management Updates.*** Hop Production Meeting. University of Wisconsin Extension. Roscholt, WI.
2.	Apr 19	***Hop diseases of Wisconsin and their diagnostics and management.*** North Central Plant Disease Diagnostic Network Meeting. Madison, WI.
3.	Mar 12	***Updates in hop disease management.*** Hop production meeting. University of Wisconsin Extension Buffalo County. LaCrosse, WI.
	2015	
4.	Aug 15	***Managing downy mildew in Wisconsin hops.*** University of Wisconsin Extension & Wisconsin Department of Agriculture, Trade, and Consumer Protection Hop Management Meeting. Albers Hop Farm. Arkensaw, WI.
5.	Aug 14	***Managing downy mildew in Wisconsin hops.*** University of Wisconsin Extension & Wisconsin Department of Agriculture, Trade, and Consumer Protection Hop Management Meeting. Davali Ridge Farm. Waterloo, WI.
6.	Mar 14	***Hop disease research and extension updates***. Gorst Valley Grower Education Meeting. Mazomanie Public Library. Mazomanie, WI.
	2014	
7.	Mar 1	***Managing diseases in Wisconsin hops: fungicide and project updates.*** University of Wisconsin Extension Hop Production Seminar. Wausau, WI.
	2013	
8.	Jul 16	***Hop Field Day.*** University of Wisconsin Extension, Arkansaw, WI.
9.	Jul 15	***Hop Field Day.*** University of Wisconsin Extension and Wisconsin Hops Exchange, Waterloo, WI.
10.	Mar 2	***Integrated Disease Management in Wisconsin Hops.*** University of Wisconsin Extension Hop Production Meeting. Wisconsin Dells, WI.

B. Compared to our intended goals, our actual accomplishments were parallel. In the case of sharing plant material for cultivar evaluation, our goal for uniform data for analyses and generation of crop management guidelines did fall short as the plantings were not easily quantified for yield and quality due to the small scale nature of the plantings. The logistics of raising and manipulating hops for study is a significant challenge.

IV. Beneficiaries

Our proposed project benefited current and future producers of hops in WI and the Midwestern region by making available planting stock free of disease for optimum growth, yield, and quality with potentially reduced reliance upon chemical control options for enhanced human and environmental safety. Results of our efforts provided increased access and cost-effectiveness of clean stock making entry into hops production more economically sound and attractive to new hobbyists and/or commercial producers. While an economic value cannot be placed on the intrinsic significance of re-establishing WI as a key hops producing location in the world, this mission drives many hops producers who take pride in the tradition of locally grown quality craft beer in WI.

Currently there are approximately 75 hops producers across the state of WI totaling approximately 320 acres of crop. Most producers have membership in one or more regional or statewide hops cooperatives or exchanges which aid in connecting market demand with production. Key organizations, such as Gorst Valley, WI Hops Exchange, and Midwest Hop and Barley Cooperative are participants in this cooperative project and are prime beneficiaries. There are 8 large and regional breweries (15,000->6 million barrels beer/year) in WI, such as Miller, Leinenkugel, New Glarus; greater than 30 microbreweries (15,000 or less barrels beer/year), such as Ale Asylum, Grumpy Troll, Hudson; and countless hobbyist brewers that would benefit from enhanced quality and quantity of Wisconsin-grown hops.

Beneficiaries received high quality, locally-sourced, and sustainably produced hops for brewing established and potentially new flavors unique to WI. Additionally, they received production knowledge on clean propagative plant generation and disease management – as well as general production guidelines through our extension and outreach mission in partnership with Carl Duley and other county extension agents.

In a 2013 grower survey in WI, IA, and MN, hops growers indicated an expected increase in acreage and farm gate value of crop by 5-fold. This increase is based on current production practices and expectations. With advancement in rhizome quality, yield and quality have likely increased resulting in expansion of acreage from 50 to 320 during the lifetime of this project. The crop value has been estimated at greater than $2.85 million during this timeframe.

V. Lessons Learned

The one delay we have experienced in conducting this project has been in acquiring plant propagative stock. In some cases, from the time of ordering to receipt of plant material several months passed and we were delayed in getting our plant collection uniformly started for early establishment efforts. This delay did result in our decision to hold back the field evaluation portion of our project until Spring/Summer 2015. All other aspects of the project moved along according to the proposed timeline. Due to this delay, we requested a no cost extension for the project until 9/30/2015. Further challenge/lesson learned is pertinent to the crop challenge of hops. A nearly 20 ft tall planting of highly intensive bines is uniquely challenging to study from a logistical perspective. Further, the newness of this industry in WI led to some design challenges of sprayer and harvest equipment technology which limited our ability to study/survey some of the critical details of crop input/output.

VI. Additional Information

Additional content pertinent to this hop project includes:

The University of Wisconsin-Madison/UWEX Vegetable Pathology website houses information within a separate crop tab on hop production and disease management (http://www.plantpath.wisc.edu/wivegdis/).

The University of Wisconsin-Madison/UWEX A3422 Commercial Vegetable Production Guide will include a hop management section in the 2017 version of the publication. Edits are currently being reviewed by our reviewer within the UWEX Learning Store publication system. This management guide is available for free online as a pdf or for approximately $10/book in hard copy (http://learningstore.uwex.edu/Assets/pdfs/A3422.pdf).

I have also provided Wisconsin and Midwestern specific guidelines for management of powdery mildew and downy mildew, in collaboration with other regional pathologists, in the Pacific Northwestern Hop Integrated Pest Management Guide published through Oregon and Washington State University Extension programs (compiled by Dr. David Gent, USDA/Oregon State Univ.).

VII. Contact Info

Amanda Gevens
Professor of Plant Pathology
University of Wisconsin - Madison
689 Russell Laboratories
1630 Linden Dr
Madison, WI 53706
(608) 890-3072
gevens@wisc.edu

4) Pest and disease forecasting for onion and carrot (FY13-004)

Report Date: November 10, 2016

I. Project Summary

In this project we implemented and optimized web, weather-based pest and disease forecasting models for enhanced management of vegetable crops grown in Wisconsin. Vegetable crops grown on muck soils in WI include onion and carrot, 2 specialty crops with significant acreage and a combined value of $17 million in 2012. The value of these crops has more than doubled from 2010 to 2012 due to an increase in acreage, yield per acre, and overall return. In part, the significant increase since 2010 was due to elevated losses resulting from erratic weather conditions that occurred in 2010; conditions that were not experienced in 2011. Despite the drought of 2012, the availability of irrigation provided for a healthy and productive crop. In 2010, above average precipitation promoted the occurrence of several aggressive foliar diseases including, Alternaria and Cercospora leaf blight in carrot and Botrytis and Downy Mildew in onion, which resulted yield losses. Environmental conditions greatly influence the occurrence and progression of foliar diseases as described. The anticipation of disease risk through the identification and monitoring of critical environmental factors can enhance management by optimizing the timing of pesticide applications. Our research aimed to mitigate disease risk by optimizing and integrating disease forecasting models to trigger the application of protectant pesticides. The pathogen and pest forecasts have been made available to vegetable producers in the 2013 Vegetable Crop Updates newsletters and on a daily basis in 2014-2015 at the UW-Vegetable Pathology website. The utility of the disease forecasts has been demonstrated through presentations at educational conferences throughout 2013-14. An onion BioIPM production manual has been initiated to serve as a companion document to the existing carrot manual. The long range goal of this work is the creation of an internet-based graphical user interface that growers can access to view disease and pest forecasts specific to their farm for multiple crops and pests.

B. This project was built on a previously funded SCBG project from 2012. This 2013 project complimented the previous work by adding additional pest and disease models to the draft website and allowed for further field validation of the web-based tools for Wisconsin production fields.

II. Project Approach

Specific Objectives:

1. We advanced the adoption of a modified TOM-CAST disease forecasting model into commercial carrot production & evaluate forecasting models for foliar diseases and pest of carrot and onion.

We conducted experiments to validate and optimize the disease and pest forecasting models further described below. For carrot, we evaluated the use of TOM-CAST driven by in-field weather stations and driven by remotely sensed data in order to determine the need for weather

stations in every field. Research plots were evaluated weekly and fungicide programs initiated when guided by TOM-CAST or when disease reached a 1% disease severity level. AUDPC and final yield data were collected and analyzed to determine if the TOM-CAST model is effective at limiting disease and maintaining yield.

In 2013, two disease forecasting models for onion, BLIGHT-ALERT and DOWNCAST, were evaluated in field trials for the management of Botrytis and downy mildew, respectively. These models use different environmental cues to calculate an action threshold. Research plots were established with two grower cooperators in Markesan and Endeavor, WI. Plots were scouted for disease weekly from mid-June to early September and all treatments contained a standard fungicide program. Additionally, experimental treatments used the BLIGHT-ALERT and DOWNCAST models to prescribe reapplication of fungicides. An additional treatment will prescribe application of fungicides based on consideration of both BLIGHT-ALERT and DOWNCAST. Onion plots were taken to harvest to assess quality, bulb number, and total weight of harvest. Unfortunately, during the field years of study, Botrytis and Downy mildew were not detected in either field plots. However, Stemphylium, an old pathogen with apparent new aggressive strains, was present in both locations (and both years) and we diverted our trial emphasis to address management of this new and concerning disease. Our data were very useful in modifying fungicide programs in Wisconsin for this disease.

2. We built a weather database to be used to drive disease and pest forecasting models.

The general infrastructure that automatically downloads weather data that can be used to implement numerous weather-based pest and disease models described in this proposal (***i.e. TOM-CAST, DOWNCAST, ALH and etc.***) as well as other pest and disease models not discussed here was established. We further built an internet-based GUI that growers can access to view disease and pest forecasts specific to their farm. This work was completed for 1) research purposes, to provide predictions that can be validated, and 2) management purposes, to inform crop management for WI muck growers. Computers housed at the UW-Madison are currently ingesting gridded weather predictions from the North American Meso-scale weather model (NAM 12km) on a daily basis from the National Weather Service (NWS). Weather data are being organized and uploaded to SQL relational database that has been created to house the forecasted weather predictions and disease and pest forecasts. Current computer code for data organization and utilization has been adapted to the gridded data structure and a new filing system was created to facilitate rapid data loading.

Computer code that implements the TOM-CAST, BLIGHT-ALERT, and ALH models based on the NAM 12km weather model has been written in a modular form to facilitate our ability to debug individual models. The running of the disease and pest models has been automated so that the models are updated daily following the download of the weather data. To optimize the large scale pest and disease forecasts, model predictions that have been calculated using NWS weather data, specific to field location, were compared to model predictions that have been calculated using field-observed data. Regression analysis were used to determine if there is a discrepancy between the action thresholds calculated using NWS weather data and those using field-based weather data. Finally, a correction factor was developed so that model predictions made over large geographic areas can be (mathematically) mapped to field-level predictions. Similar to Objective 1, AUDPC and yield data from each of the research plots were collected and analyzed

to determine if the TOM-CAST model, driven by NWS weather data, is effective at controlling disease. For research purposes, model predictions can currently be output daily although this functionality requires manual manipulation and export of data files. In cooperation with a private IT company, an internet-based GUI was created to automate the functionality of the database. This GUI will be made available to vegetable growers in the state of Wisconsin to be used as a tool to better manage their crops. This website will be linked to the UW Vegetable Pathology and Entomology websites.

3. Develop and disseminate extension material to producers

This project was introduced at the 2013 Wisconsin Potato and Vegetable Growers Association (WPVGA)\UW Extension Annual Muck Meeting and the Central Wisconsin Processing Crops Meeting and has been met with interest from vegetable producers. This aspect of the proposal has aided in the dissemination of the research results and increased the adoption of the weather based spray programs thereby increasing the efficiency of vegetable production in WI. The functionality of this new tool has been discussed and demonstrated at commodity meetings.

Growers, extension field faculty, and crop advisors rely heavily on annually revised, pest management recommendations. As specific tactics are tested and validated in field trials, forecast-driven practices were highlighted in the weekly Vegetable Crop Updates newsletter and posted online. Results will also be used to create new or update existing extension pest management publications.

Annual field days at stations were an important educational venue that allowed growers and clientele to observe first hand, research methods and results from field studies. We recognized the importance of peer-to-peer sharing of information and understand that early adopters were crucial in effecting change in the industry.

Our on-farm research collaboration aided in the successful completion of our research objectives and served as a point-of-entry for implementing new management strategies. For example, they directly engage growers in new technology and demonstrate advantages of adoption. Growers often rely on other growers as a source of information for pest management advice. By conducting on-farm tests with leaders of the industry we will take advantage of this dissemination mechanism.

III. Goals and Outcomes Achieved

A. Our project addressed several of the 2013 Funding Priorities of the Wisconsin Specialty Crop Block Grant Program. We increased the availability of disease-free rhizomes, and selected varieties that have genetic resistance to pests and diseases, improving pest and disease control in Wisconsin hop yards. Hop varieties selected for pest and disease resistance, and for agronomic performance in Wisconsin conditions, have, in general, required fewer inputs and were, thus, more environmentally sustainable. Our educational efforts in each of the project years has established a regular demand for continued, progressive, sessions to hop growers (novice to experienced) from within Wisconsin and from surrounding states. Our programming has led to partnerships with other states' land extension programming as well as with the Great Lakes Hops Working Group funded by the north central Integrated Pest Management resource.

Products of this project included:

EXTENSION PUBLICATIONS
Single Print Extension Bulletins

Gevens, A.J., Marks, M.E. 2014. *Hop Downy Mildew: Identification and Management*. UW-Extension Publication.

Gevens, A.J., Marks, M.E. 2014. *Hop Powdery Mildew: Identification and Management*. UW-Extension Publication.

Gevens, A.J., Marks, M.E. 2014. *Hop Viruses: Identification and Management*. UW-Extension Publication.

Trade Journal Publications

Marks, M.E., Gevens, A.J. 2015. What's hoppin' in Wisconsin hops?! Fresh. A magazine of the Wisconsin Fresh Market Fruit and Vegetable Growers Association (April Edition).

Newsletter Articles

Gevens, A.J. 2016. Vegetable disease update: DSV (Blitecast, Late Blight) and P-Day (Early Blight) updates, late blight and cucurbit downy mildew national updates, powdery mildew on hops, diagnostic updates. *Wisconsin Crop Manager*, Vegetable Crop Updates #23. August 12.

Gevens, A.J. 2016. Vegetable disease updates: DSV (Blitecast, Late Blight) and P-Day (Early Blight) updates, early season late blight symptoms and inoculum sources; management link to potato blackleg seminar from Focus on Potato, WI hop updates. *Wisconsin Crop Manager*, Vegetable Crop Updates #9. May 27.

Gevens, A.J. 2016. Vegetable disease updates: national late blight updates, hop downy mildew updates for Wisconsin. *Wisconsin Crop Manager*, Vegetable Crop Updates #5. April 29.

Gevens, A.J. 2015. Potato fungicide updates for 2015: new registrations and label updates. Hop disease identification and management. *Wisconsin Crop Manager*, Vegetable Crop Update #2. April 3.

Gevens, A.J. 2014. Vegetable disease update: Potato production updates, Late Blight Updates, Blitecast and P-Days for late blight and early blight management, Cucurbit downy mildew update, Hops update. *Wisconsin Crop Manager*, Vegetable Crop Update #13. July 11.

Gevens, A.J. 2014. Vegetable disease update: Late blight reminders, updates, and a look at Blitecast, Hop downy mildew detected in Portage and Dane Counties, Cucurbit downy mildew -- info resources. *Wisconsin Crop Manager*, Vegetable Crop Update #6. May 23, 2014. (Spanish Version Available)

Gevens, A.J. 2014. Vegetable disease update: Early Season Hop Update, Considerations for organic late blight control. *Wisconsin Crop Manager*, Vegetable Crop Update #3. April 28, 2014. Spanish Version Available Online.

Gevens, A.J. 2013. Vegetable disease update: early season damping-off and hop downy mildew. *Wisconsin Crop Manager*, Vegetable Crop Update #4. May 11, 2013.

Local and State Presentations

	Date	***Presentation title, e*vent, and location**
	2016	
2.	Jul 8	***Hop Disease Management Updates.*** Hop Production Meeting. University of Wisconsin Extension. Roscholt, WI.
3.	Apr 19	***Hop diseases of Wisconsin and their diagnostics and management.*** North Central Plant Disease Diagnostic Network Meeting. Madison, WI.
4.	Mar 12	***Updates in hop disease management.*** Hop production meeting. University of Wisconsin Extension Buffalo County. LaCrosse, WI.
	2015	
5.	Aug 15	***Managing downy mildew in Wisconsin hops.*** University of Wisconsin Extension & Wisconsin Department of Agriculture, Trade, and Consumer Protection Hop Management Meeting. Albers Hop Farm. Arkensaw, WI.
6.	Aug 14	***Managing downy mildew in Wisconsin hops.*** University of Wisconsin Extension & Wisconsin Department of Agriculture, Trade, and Consumer Protection Hop Management Meeting. Davali Ridge Farm. Waterloo, WI.
7.	Mar 14	***Hop disease research and extension updates***. Gorst Valley Grower Education Meeting. Mazomanie Public Library. Mazomanie, WI.
	2014	
8.	Mar 1	***Managing diseases in Wisconsin hops: fungicide and project updates.*** University of Wisconsin Extension Hop Production Seminar. Wausau, WI.
	2013	
9.	Jul 16	***Hop Field Day.*** University of Wisconsin Extension, Arkansaw, WI.
10.	Jul 15	***Hop Field Day.*** University of Wisconsin Extension and Wisconsin Hops Exchange, Waterloo, WI.
11.	Mar 2	***Integrated Disease Management in Wisconsin Hops.*** University of Wisconsin Extension Hop Production Meeting. Wisconsin Dells, WI.

B. Compared to our intended goals, our actual accomplishments were parallel. In the case of sharing plant material for cultivar evaluation, our goal for uniform data for analyses and generation of crop management guidelines did fall short as the plantings were not easily quantified for yield and quality due to the small scale nature of the plantings. The logistics of raising and manipulating hops for study is a significant challenge.

IV. Beneficiaries

Our proposed project benefited current and future producers of hops in WI and the Midwestern region by making available planting stock free of disease for optimum growth, yield, and quality with potentially reduced reliance upon chemical control options for enhanced human and environmental safety. Results of our efforts provided increased access and cost-effectiveness of clean stock making entry into hops production more economically sound and attractive to new hobbyists and/or commercial producers. While an economic value cannot be placed on the intrinsic significance of re-establishing WI as a key hops producing location in the world, this mission drives many hops producers who take pride in the tradition of locally grown quality craft beer in WI.

Currently there are approximately 75 hops producers across the state of WI totaling approximately 320 acres of crop. Most producers have membership in one or more regional or statewide hops cooperatives or exchanges which aid in connecting market demand with production. Key organizations, such as Gorst Valley, WI Hops Exchange, and Midwest Hop and Barley Cooperative are participants in this cooperative project and are prime beneficiaries. There are 8 large and regional breweries (15,000->6 million barrels beer/year) in WI, such as Miller, Leinenkugel, New Glarus; greater than 30 microbreweries (15,000 or less barrels beer/year), such as Ale Asylum, Grumpy Troll, Hudson; and countless hobbyist brewers that would benefit from enhanced quality and quantity of Wisconsin-grown hops.

Beneficiaries received high quality, locally-sourced, and sustainably produced hops for brewing established and potentially new flavors unique to WI. Additionally, they received production knowledge on clean propagative plant generation and disease management – as well as general production guidelines through our extension and outreach mission in partnership with Carl Duley and other county extension agents.

In a 2013 grower survey in WI, IA, and MN, hops growers indicated an expected increase in acreage and farm gate value of crop by 5-fold. This increase is based on current production practices and expectations. With advancement in rhizome quality, yield and quality have likely increased resulting in expansion of acreage from 50 to 320 during the lifetime of this project. The crop value has been estimated at greater than $2.85 million during this timeframe.

V. Lessons Learned

The one delay we have experienced in conducting this project has been in acquiring plant propagative stock. In some cases, from the time of ordering to receipt of plant material several months past and we were delayed in getting our plant collection uniformly started for early establishment efforts. This delay did result in our decision to hold back the field evaluation portion of our project until Spring/Summer 2015. All other aspects of the project on moving along according to the proposed timeline. Due to this delay, we have requested a no cost extension for the project until 9/30/2015. Further challenge/lesson learned is pertinent to the crop challenge of hop. A nearly 20 ft tall planting of highly intensive bines is uniquely challenging to study from a logistical perspective. Further, the newness of this industry in WI led to some design challenges of sprayer and harvest equipment technology which limited our ability to study/survey some of the critical details of crop input/output.

VI. Additional Information

Additional content pertinent to this hop project includes:

The University of Wisconsin-Madison/UWEX Vegetable Pathology website houses information within a separate crop tab on hop production and disease management (http://www.plantpath.wisc.edu/wivegdis/).

The University of Wisconsin-Madison/UWEX A3422 Commercial Vegetable Production Guide will include a hop management section in the 2017 version of the publication. Edits are currently being reviewed by our reviewer within the UWEX Learning Store publication system. This management guide is available for free online as a pdf or for approximately $10/book in hard copy (http://learningstore.uwex.edu/Assets/pdfs/A3422.pdf).

I have also provided Wisconsin and Midwestern specific guidelines for management of powdery mildew and downy mildew, in collaboration with other regional pathologists, in the Pacific Northwestern Hop Integrated Pest Management Guide published through Oregon and Washington State University Extension programs (compiled by Dr. David Gent, USDA/Oregon State Univ.).

VII. Contact Info

Amanda Gevens
Professor of Plant Pathology
University of Wisconsin - Madison
689 Russell Laboratories
1630 Linden Dr
Madison, WI 53706
(608) 890-3072
gevens@wisc.edu

5) Improving American hazelnut germplasm for growers in the upper Midwest (FY13-005)

Report Date: November 7, 2016

I. Project Summary

Hazelnuts are a long-lived perennial shrub producing nuts rich in oleic acid. The kernels have potential in fresh-eating, processed foods, salad oils, cosmetics, bio-fuels, and bio-industrial markets. Hazelnuts are envisioned as a foundational species in perennial-based agriculture systems that provides enhanced ecosystem services AND significant economic returns to producers. Such systems could reduce the need for costly government set-aside programs such as CRP.

Hazelnut production in the U.S. is limited to the Willamette Valley of Oregon and is based on cultivars of European hazelnut (*Corylus avellana*), which will not grow in the Upper Midwest. Currently, North America is a net exporter of hazelnuts, but that is likely to change in the coming years as companies such as Peer Ferrero (Nutella®) and J.M. Smuckers (Jif Hazelnut Spreads®) aggressively seek to develop the North American market for spreadable hazelnut butters. A new production facility owned by Ferrero Canada, Inc. in Ontario imports 10,000 metric tons of shelled hazelnuts per year with a planned increase to 25,000 tons by 2015 (Dale and Kelly, 2013). This equates to roughly 50,000 acres of new demand. If market penetration for Nutella® in North America approaches levels currently seen in France, demand for new hazelnut production will increase 36 times over current levels.

Turkey is the largest producer of hazelnuts in the world with nearly 80% of total production, most of which is in small plantings less than 1 acre in size. Turkish production is in decline and new production in Oregon is limited by available land and cultivar susceptibility to eastern filbert blight. As such, there is significant market pull developing for new domestic production of hazelnuts. In addition, if the high oleic acid hazelnut oil can be produced cheaply enough from the hedge-row based system envisioned for the Upper Midwest, perennial hazelnuts could be a truly sustainable biofuel crop with, essentially, unlimited market potential.

Ongoing work by the Upper Midwest Hazelnut Development Initiative, the Arbor Day Hazelnut Consortium, and the Ontario Hazelnut Association are looking to establish new North American hazelnut production through development of novel hazelnut cultivars derived from hybrids of European hazelnut and our native species, American hazelnut (*Corylus americana*). These new cultivars must be cold-hardy, productive, and have durable (quantitative) tolerance to eastern filbert blight.

<u>Wisconsin Hazelnut Research Team</u>

As collaborators in the Upper Midwest Hazelnut Development Initiative, the Wisconsin Hazelnut Research Team, has been working since 2007 to assist growers in development of a hazelnut industry with focus in three primary areas: 1) grower outreach and education, 2) development of

suitable propagation technology for replicated research trials and eventual commercialization, and 3) development of locally-adapted genotypes from hybrid and American populations.

The primary focus of the Wisconsin Hazelnut Research Team is on American hazelnut. It is found throughout the Great Lakes region, particularly in Wisconsin, and because it is endemic to the region it has evolved with the climate and pest pressures, and as such, presents a logical (and perhaps faster) path toward development of commercial plant material for the Upper Midwest. Furthermore, it is a tremendous biological resource that has never been adequately explored. Existing hybrid hazelnut populations and other breeding programs in the U.S. are based on European genetics with only limited selections from American populations.

Prior work, funded in part by a FY2009 grant from the WI SCBG program, demonstrated that within-population genetic diversity in wild populations of American hazelnuts is greater than among-population diversity. This validated our efforts to select high-performing accessions from wild populations via mass selection. To date, we have collected 85 such accessions. In addition, we had developed an initial approach to micro-propagation for generation of copies of the accessions for replicated evaluation at multiple locations.

The purpose of this project was to establish replicated trials at three locations in Wisconsin clonal propagules of the top American hazelnut selections. In addition, to begin developing the market pull for hazelnuts and to better understand the flavor characteristics of American hazelnut kernels we proposed to evaluate kernel quality compared to industry hazelnut standards. Finally, our intention was to begin a controlled crossing program with the top American hazelnut selections to begin testing F1 progeny.

B. This project continued the work done in the FY 2009 project titled: "Improving Bush-Type Hazelnuts for Commercial Production through Cooperative Regional Breeding and Evaluation". In that project we screened 35 wild populations of *C. americana* across Wisconsin and selected 85 high performing accessions. These accessions were transferred to the Bayfield Performance Trial for archiving and evaluation. In addition the project began the process of evaluating the genetic diversity of *C. americana* across the Upper Midwest to better guide future mass selection work.

This project continued the work of Brent McCown and Knight Hollow Nursery to develop micro-propagation protocols for moving the high performing accessions into replicated performance trials. This step is key, because though the accessions were high-performing in the wild, we don't really know how they perform in cultivated situations (better fertility, moisture, and weed control) or until replicated across multiple environments. We knew going into this project that hazelnuts are not easily vegetatively propagated.

II. Project Approach

1. Establish replicated performance trials for evaluation of clones of initial selections of American hazelnut at three locations in Wisconsin.

Propagation of hybrid and pure American hazelnuts continues to be a challenge and is the bottleneck for our project and development of the industry in the Upper Midwest. Knight

Hollow Nursery is working on propagation here in Wisconsin and since this project was funded we have also been collaborating with Dr. Jerry Cohen in Minnesota. Together, we have not yet solved the propagation challenge. As such, we have not yet populated our replicated performance trials with clonal material from our initial American hazelnut selections. This project has allowed us, however, to make significant progress in developing a protocol that works across genotypes. In addition, despite not having clonal material we have populated the performance trials with half-sibling seedlings from our top producing *C. americana* plants. Thus, our goal of advancing the use of our native *C. americana* in a regional hazelnut breeding program has been accomplished.

Micro-propagation generally has five main phases: 1) Development of juvenile source material, 2) Isolation of material in culture, 3) Stabilization of the culture sufficient to harvest shoots from axillary buds for scale-up in culture, 4) Rooting of micro-cuttings and acclimation to greenhouse conditions, 5) Production of field-ready liners with successful acclimation to field conditions.

Through this project we have been successful with phases 1 and 2 with 12 *C. americana* genotypes and 20+ hybrid genotypes. We have also successfully moved 1 *C. americana* genotype through all five phases. However, there is considerable genetic diversity among these selections and we have had variable results moving other genotypes through phases 3 and 4 and we don't yet know why. In addition, the isolation and stabilization phases can be at least 6 months long making the process incredibly slow. The main problem being that axillary bud formation and, thus, generation of micro-cuttings is very slow and the plants do not respond well to cytokinins. Higher levels of cytokinins tend to result in problems of vitrification. At this point, our main challenges are the length of the isolation and stabilization phase and the lack of dormant bud development on rooted micro-propagules. In other words, once out of the stabilization phase we can produce roots and decent greenhouse growth, but most of the rooted micro-cuttings fail to set buds once dormancy is induced and the propagules die.

We currently have the *C. americana* accessions still in one phase or another and we have secured some additional (but limited) funding to continue working on the propagation to eventually populate the replicated trials. Our collaboration with Dr. Jerry Cohen will also broaden the effort.

In lieu of clonal material from the *C. americana* accessions, we generated half-sib offspring from seed from the archived accessions at Bayfield and populated trials at five locations with this material. This will allow us to evaluate the offspring for desirable trials for future breeding efforts. This work is described in more detail below.

2. Evaluate the kernel quality of selections of American hazelnuts.

As reported previously, the taste and sensory components of 11 accessions of American hazelnut were evaluated by North Carolina State University with many of the accessions comparing favorably or better than the industry standard variety, Tonda Di Giffoni. In addition, the sphericity of the 11 accessions is more than adequate for industrial roasting processes. As such, American hazelnut has potential to provide unique and superior taste characteristics for the marketplace.

A manuscript reporting on the results of this work "Physical characteristics and sensory analysis of American hazelnuts in comparison to Tonda di Giffoni" has been published in the Agroforesty Systems journal. http://link.springer.com/article/10.1007/s10457-016-9898-y

3. Develop a micro-propagation protocol to generate clonal material from embryos isolated from American hazelnut seeds.

In 2014, we harvested nuts from the oldest American hazelnut selections in our replicated clone trials and Knight Hollow chemically remove dormancy from the seeds and germinated them in December 2014. The plants were grown to generate enough material for harvesting and rooting cuttings. As was experienced with the micro-cuttings from the tissue culture work, the rooting and subsequent growth in these initial trials was poor. With the discovery of the importance of nickel and iron, growth rates have been improved, but bud set prior to dormancy continues to be a challenge. Thus, generating clonal propagules from a seedling is possible and in some ways is easier as the main stem and nodal cuttings are juvenile, but the same problems encountered in rooting and acclimating micro-propagules through the dormancy phase remain.

4. Generate clonal off-spring from controlled crosses of select American hazelnut accessions for evaluation in replicated performance trials.

Half-Sib Hazelnut Seedling Orchard at the Hayward State Tree Nursery. 2000 plants and counting…

The original *C. americana* accessions were transplanted into pots (and archived at the Bayfield planting) via collar division. The plants grow well in the pots and our intention was to grow them large enough to do controlled crossing. However, we've had to use the potted plants to generate and harvest juvenile shoots for the propagation work. Instead, we've been waiting on the field archived plants to reach maturity and start flowering. In 2014 and 2015, we were able to harvest small amounts of seed. This seed was sprouted and the plants have been transplanted to five trial locations in Wisconsin (Bayfield Hazelnut Performance trial at Seven Ponds Winery in Bayfield, Treehaven in Tomahawk, the Hayward State Tree Nursery in Hayward, the Spooner Ag Research Station in Spooner, and at Cranberry Creek Cranberries near Finley. We will be evaluating the material over the coming years for yield, disease resistance, and kernel quality. Going forward, once the propagation challenge is solved we intend to develop clonal material from additional controlled crosses.

Again in lieu of generating clonal propagules, we have been continuing our *C. americana* collections from wild populations with a focus on collecting seed from high-performing plants. We now have more than 2000 *C. americana* hazelnut plants at the Hayward State Tree Nursery, each of which is genetically unique and comes from wild-grown female plants with the demonstrated ability to produce yields that exceed that of neighboring plants. This planting represents a

novel source of hazelnut genetic material that will be a resource for our project, but also the larger effort to develop hazelnuts in North America outside the Pacific Northwest.

III. Goals and Outcomes Achieved

- **A.** Continued to work on micro-propagation of American Hazelnuts for production of clonal propagules using juvenile shoots from mature selections.
- Began work on micro-propagation of American Hazelnut using material harvested from early-growth seedlings.
- Germinated, grew, and transplanted half-sibling seedlings from C. americana accessions at five locations in Wisconsin (Bayfield, Hayward, Spooner, Tomahawk, and Finley).
- Maintained and managed the existing C. americana plantings at Bayfield and Hayward.
- Harvested, husked, and weighed nuts from individual plants at the Bayfield and Spooner plantings.
- Evaluated the kernel quality of C. americana accessions in comparison to the industry standard European hazelnut, Tonda Di Giffoni.
- Published the results of the kernel quality in a journal article. Presented the results at the Upper Midwest Hazelnut Growers Conference with the presentation archived on the Proceedings page of the UMHDI website: www.midwesthazelnuts.org.

B. The original intended outcomes in the 2013 proposal were: 1) Populate replicated performance trials with clonal propagules of our top *C. americana* accessions in order to evaluate performance across a range of environments and in comparison to other *C. americana* and hybrid selections. 2) Evaluate the flavor of *C. americana* accessions with the goal of both demonstrating and finding flavor quality that equaled or exceeded industry standard European varieties. 3) Develop a protocol for cloning *C. americana* offspring using embryos in order to speed the genetic evaluation timeline. 4) Establish a controlled crossing block to generate and plant clonal material from the full sibling seedlings.

Because we have not yet perfected a vegetative propagation protocol for the *C. americana* selections we have not yet fully achieved outcomes 1, 3, and 4. We continue to make progress toward these outcomes, but did not fully realize them within the timeline of this grant project. For this reason we have not fully expensed the grant. However, to continue building the genetic resource and making progress toward developing proven commercially-viablecultivars, we have established trial planting with half-sibling seedlings sourced from wild populations and from the *C. americana* accessions themselves. These trials are at five locations in Wisconsin. This genetic resource will be ready to fully utilize once the vegetative propagation is figured out.

We were successful in meeting our goals for outcome 2. We performed a sensory flavor and physical characteristic analysis of *C. americana* accessions and published the work in a journal and in the proceedings of our annual conference. Growers await the clonal propagules.

IV. Beneficiaries

The individual hazelnut growers in the Upper Midwest and their organizations such as the Minnesota Hazelnut Foundation, Iowa Nut Growers, Rural Advantage, Savanna Institute, and

American Hazelnut Company will eventually benefit from our work in the form of improved plant material. In the interim they have learned valuable information about kernel quality of American hazelnut. The Oregon industry views American hazelnut as primarily a source of EFB resistance. However, through our work, we have shown that American hazelnut is a source of other desirable traits such as superior flavor and sphericity (to aid even roasting). This will allow the Upper Midwest industry to differentiate its products in the marketplace.

We communicated updates and the results of our work at the annual Wisconsin Hazelnut Field Day and the Upper Midwest Hazelnut Growers Conference. The WI field day was held in Bayfield in 2016 (25 attendees), in Stoughton in 2014 (52 attendees), and in Viola in 2013 (57 attendees). The growers conference was held in Gays Mills in 2016 (101 attendees), in Gays Mills in 2014 (89 attendees), and in Eau Claire in 2013 (98 attendees). In lieu of the 2015 field day and conference, WI hosted the annual meeting and conference of the Northern Nut Growers Association. UMHDI researchers presented at both the classroom sessions and during the tour of the American Hazelnut Company and New Forest Farm in Viola, WI (117 attendees). In addition to the field days and conferences, Jason Fischbach has provided research updates since 2013 to the Ontario Hazelnut Growers Association annual meeting (145 attendees), the WACEC Northern District Tour (35 attendees), Tri-State Forest Stewardship Conference (89 attendees), USDA Agroforestry Academy (38 attendees), Wisconsin Public Television Science Night, and the MOSES Organic University. Jason also has managed the Upper Midwest Hazelnut Development Initiative website (www.midwesthazelnuts.org).

Our work to establish the half-sibling seedling orchard at the Hayward State Tree Nursery is helping establish a relationship with the forestry division of the WI DNR. The seed harvested from the plants will be made available to the DNR for their wildlife shrub program. In addition, we intend for the proven C. americana selections to be available to the DNR (and private growers) specifically as an improved wildlife habitat shrub.

V. Lessons Learned

The sensory analysis work was a very positive discovery that showed (what growers were telling us) that the flavor of C. Americana is very good and even better than hazelnuts from European cultivars. The diversity of flavor quality, however, reflects the genetic diversity of American hazelnut populations and shows the importance of a vigorous germplasm development program.

The propagation problem is greatly frustrating as we have identified select plant material from both the wild and hybrid populations, but are not yet able to make it available to growers. We are not alone, however, as propagators across the country have been struggling with hybrid and C. Americana propagation. It is our intent to host a symposium during the winter of 2016-2017 to develop a strategy to figure out propagation.

The new plantings with half-sib seedlings is a great genetic resource that will aid hazelnut breeding for generations to come. Wild populations have been an untapped genetic treasure in our region and we are now finally able to utilize that resource.

VI. Additional Information

None

VII. Contact Info

Jason Fishbach
UW Extension Agent
Bayfield County
P.O. Box 218
Washburn, WI 54891
715-373-6104
jason.fischbach@ces.uwex.edu

6) Developing IPM for high tunnel tomatoes (FY13-006)

Report Date: September 19, 2016

I. Project Summary

In this project, we developed integrated, best management practices for production of tomatoes in high tunnels in Wisconsin for enhanced yield, quality, return on investment, and environmental sensitivity. High tunnel construction for season extension and conservation of lands in agricultural production has greatly increased in Wisconsin over the past decade as a result of the federal National Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) program. The EQIP program has supported production of seasonal polyethylene covered structures (termed high tunnels) to extend the growing season with the goals of improving plant, soil, and air quality, reducing nutrient and pesticide transport, and reducing energy use through local consumption. Tomato is a high value specialty crop and one of the most commonly grown vegetable crops in Wisconsin high tunnels. Environmental conditions within the high tunnel are different than in open-field and require customized production recommendations that have, to date, come from extrapolation from field trials and from high tunnel research of other regions. The most common disease on high tunnel tomatoes is leaf mold, which is easily diagnosed and can potentially limit photosynthetic capacity, yet little information is available on yield and quality impact of the pathogen.

We conducted projects which aimed to i) advance integrated management strategies for tomato production in high tunnels in Wisconsin, and ii) determine an economic threshold and integrated management for tomato leaf mold in the high tunnel. Additionally, we developed a biointensive IPM manual for high tunnel tomato production in Wisconsin, and coordinated numerous educational opportunities with UWEX to disseminate our findings.

B. This was a new project request which built on results of efforts supported by SCBG 12-009. The 2013 project was able to further our impact in developing production management recommendations and extension deliverables to growers due to the fact that the 2012 project connected us with several impactful growers who greatly contributed to our knowledge base. Additionally, the previous project generated survey data which helped us identify key areas of management concerns in Wisconsin so that we could best tailor our programming in research and extension.

II. Project Approach

The overall objective of this project was to develop integrated, best management practices for disease control in production of tomatoes in high tunnels in WI for enhanced yield, quality, return on investment, and environmental sensitivity. Individual sub-objectives are reported on, below.

1) We developed a crop profile for high tunnel tomato in Wisconsin. Establishment of a crop profile for tomatoes raised in commercial Wisconsin high tunnels has provided a baseline of

incidence and severity of pest, pathogen, and abiotic factors, as well as an outline of common agronomic practices on which enhanced best management practices can continue to be developed. Tomatoes produced in high tunnels have pests and pathogens, and other production considerations that are unique to the high tunnel system. Bi-weekly scouting of 3 commercial high tunnel tomato production facilities were conducted. Commercial collaborators included Scott Witte of Witte's Vegetable Farm (Cedarburg, WI), Jack Buchanan of Jack's Fresh Produce (Hancock, WI), and Tiffany Cade and Jimmy Fackert of Deep Rooted Organics (Westby, WI). Plant parameters such as physiological stage of growth, overall plant health, insect, weed, and disease were recorded. Data were collected uniformly at each observation site and data were aggregated, analyzed, and summarized in development of a crop profile and well as a BioIPM manual for high tunnel tomato production.

2) We worked toward characterizing an economic threshold of leaf mold caused by the fungus *Fulvia fulvum* and we developed a best management practice for disease management in commercial high tunnel tomato production systems. Leaf mold was monitored at 3 commercial collaborator locations and 2 experimental research locations in Wisconsin. At each location we evaluated the efficacy of foliar disease management programs and varieties for control of leaf mold and resulting overall yield. We also more carefully evaluated varieties for leaf mold control in detached leaflet assays in the laboratory. All treatment structures/varieties were replicated four times in multiple locations. Leaf mold, in addition to Botrytis (*Botrytis cinerea*), and other incidental diseases were evaluated every 2 weeks on a 0-11 modified Horsfall Barratt disease rating scale and Area Under the Disease Progress Curve or AUDPC was determined. Appropriate statistical analyses were applied to data and determination of greatest yield/quality and market value were determined for each treatment.

3) We shared results of our work to the production community through multiple communication venues. Commodity meetings. Presentations at commodity meetings reach large audiences. The PIs of this project annually delivered presentations at multiple commodity meetings that reached virtually all target audiences in participating states and beyond. Extension publications. Growers, extension field faculty and crop advisors rely heavily on annually revised, pest management recommendations. Results were highlighted in the weekly Vegetable Crop Updates newsletter, also posted online. Results were also used to create a new (BioIPM manual for tomato high tunnel production, to be published/printed in 2017). Hardcopies will be distributed at field days and commodity meetings, and an electronic version will be available on the web. Field days and grower contacts. Annual field days at stations were an important educational tool that allowed growers and clientele to see research methods and results first hand in the field. On-farm tests. On-farm tests with Mr. Jack Buchanan were a major component of our research and also served as excellent implementation tool. The work directly engaged growers in new technology and demonstrate advantages of adoption. Growers often rely on other growers as a source of information for pest management advice.

III. Goals and Outcomes Achieved

GOAL 1: increased outreach of production recommendations based on UW research to promote optimized pest and leaf mold control & crop management.

Outcome: We influenced a 10% grower shift in management strategies to include leaf mold control earlier in the production season in high tunnels due to results of this study. The outcome was monitored by comparing production practice survey information from one year to the next (2014-15). Initial or baseline information was collected at the WI fresh market vegetable growers association education meeting held in Jan 2014, Wisconsin Dells, WI; subsequent information collection took place during the same meeting in Jan 2015. Verbal survey results were analyzed and summarized to address this project objective.

GOAL 2: enhanced yield and economic return on investment.
Outcome: The core purpose of this proposal addressed the sustainability of high tunnel tomato production in WI through enhanced production practices. Our verbal survey, as outlined above (performed at WI fresh market vegetable growers association education meeting held in January 2014 and 15, Wisconsin Dells, WI, indicated that there was a relatively consistent number of growers and high tunnels across the year span of time. However, the awareness of disease concerns and improved response to disease within the high tunnels resulted in increased yield and quality of tomato. Growth in the production of high tunnel tomatoes will indicate additional successes and areas for potential industry expansion – however – this was not reflected in the survey conducted in 2014-5.

B. Overall, our intended accomplishments were in line with our actual accomplishments. However, our impact was focused on aspects of disease detection and management rather than the complete production system. The production, whole system recommendations on fertility, insect, weed management and row spacing were more greatly impacted/adjusted through our expanded engagement with growers and other high tunnel producers across the state of WI and within the upper Midwestern region.

Products of this project included:

EXTENSION PUBLICATIONS

Single Print Extension Bulletins

Gevens, A.J., Wilbur, J. 2014. *Tomato Late Blight: Identification and Management*. UW-Extension Publication.

Trade Journal Publications

Gevens, A.J. 2015. Late blight in 2015: from sea to shining sea. Fresh. A magazine of the Wisconsin Fresh Market Fruit and Vegetable Growers Association (November Edition).

Gevens, A.J. 2015. Late blight in 2015: from sea to shining sea. The Badger Beat. The Badger Common Tater. October 2015 Edition.

Gevens, A.J., Groves, R.L. 2015. Advancing weather-based tools for anticipating and managing vegetable diseases and insect pests in Wisconsin. Fresh. A magazine of the Wisconsin Fresh Market Fruit and Vegetable Growers Association (August Edition).

Gevens, A.J. 2014. Continuing the blight flight in 2014. The Badger Beat. The Badger Common Tater. October 2014 Edition.

Gevens, A.J. 2013. Unpacking late blight. The Badger Beat. The Badger Common Tater. Vol 65(10): 11-13.

Newsletter Articles

Gevens, A.J. 2016. Vegetable disease update: DSV (Blitecast, Late Blight) and P-Day (Early Blight) updates, late blight and cucurbit downy mildew national updates, tomato anthracnose. *Wisconsin Crop Manager*, Vegetable Crop Updates #25. August 26.

Gevens, A.J. 2016. Vegetable disease update: DSV (Blitecast, Late Blight) and P-Day (Early Blight) updates, late blight and cucurbit downy mildew national updates, powdery mildew on hops, diagnostic updates. *Wisconsin Crop Manager*, Vegetable Crop Updates #23. August 12.

Gevens, A.J. 2016. Vegetable disease update: DSV (Blitecast, Late Blight) and P-Day (Early Blight) updates, late blight and cucurbit downy mildew national updates, cucurbit powdery mildew updates, fungicides for conventional control of tomato late blight. *Wisconsin Crop Manager*, Vegetable Crop Updates #21. July 29.

Gevens, A.J. 2016. Vegetable disease updates: DSV (Blitecast, Late Blight) and P-Day (Early Blight) updates, early season late blight symptoms and inoculum sources; management link to potato blackleg seminar from Focus on Potato, WI hop updates. *Wisconsin Crop Manager*, Vegetable Crop Updates #9. May 27.

Gevens, A.J. 2016. Vegetable disease updates: national late blight updates, hop downy mildew updates for Wisconsin. *Wisconsin Crop Manager*, Vegetable Crop Updates #5. April 29.

Gevens, A.J. 2015. Potato fungicide updates for 2015: new registrations and label updates. Hop disease identification and management. *Wisconsin Crop Manager,* Vegetable Crop Update #2. April 3.

Gevens, A.J. 2014. Vegetable disease update: Potato production updates, Late Blight Updates, Blitecast and P-Days for late blight and early blight management, Cucurbit downy mildew update, Hops update. *Wisconsin Crop Manager,* Vegetable Crop Update #13. July 11.

Gevens, A.J. 2014. *Wisconsin Crop Manager,* Vegetable Crop Updates Disease Supplement #4. Late blight in Milwaukee County on tomato is US-23 clonal lineage. August 6.

Gevens, A.J. 2014. Vegetable disease update: Late Blight Updates, Blitecast and P-Days for late blight and early blight management, Cucurbit downy mildew update, Onion downy mildew in WI. *Wisconsin Crop Manager,* Vegetable Crop Update #16. August 2.

Gevens, A.J. 2014. *Wisconsin Crop Manager,* Vegetable Crop Updates Disease Supplement #3. Late blight in Milwaukee County on tomato. July 30.

Gevens, A.J. 2014. Vegetable disease update: Late blight reminders, updates, and a look at Blitecast, Hop downy mildew detected in Portage and Dane Counties, Cucurbit downy mildew -- info resources. *Wisconsin Crop Manager,* Vegetable Crop Update #6. May 23, 2014. (Spanish Version Available)

Gevens, A.J. 2014. Vegetable disease update: Early Season Hop Update, Considerations for organic late blight control. *Wisconsin Crop Manager,* Vegetable Crop Update #3. April 28, 2014. Spanish Version Available Online.

Gevens, A.J. 2013. Vegetable disease update: Bravo update, high tunnel tomato, DSVs/Blitecast. *Wisconsin Crop Manager,* Vegetable Crop Update #6. June 1, 2013. Spanish Version Available Online.

Gevens, A.J. 2013. Vegetable disease update: DSVs/Blitecast, P-Days for Early Blight, Tomato Leaf Mold, and Cucurbit Downy Mildew. *Wisconsin Crop Manager,* Vegetable Crop Update #14. July 30, 2013. Spanish Version Available Online.

Gevens, A.J. 2013. Vegetable disease update: DSVs/Blitecast, P-Days for Early Blight, Cucurbit Downy Mildew, Black Rot in cabbage, Tomato bacterial diseases. *Wisconsin Crop Manager,* Vegetable Crop Update #11. July 9, 2013. Spanish Version Available Online.

Radio release and appearances

Gevens, A.J. University of Wisconsin College of Agricultural and Life Sciences News Audio piece. Late blight updates in potato and tomato. Release date August 7, 2014.

Gevens, A.J. University of Wisconsin College of Agricultural and Life Sciences News Audio piece. Late blight resistance in tomato. Release date March 1, 2013.

Proceedings

Seidl, A.C., **Gevens, A.J.** 2013. Characterization of *Phytophthora infestans* causing late blight in Wisconsin tomato and potato crops from 2009-2012. Poster. *In* Proceedings of Wisconsin's Annual Potato Meeting, UW-Madison College of Agriculture and Life Sciences, Research Division and UWEX, Feb. 5-7, Stevens Point, WI, 26:220.

Gevens, A.J. 2012. Integrated Management of Common and Infamous Foliar Diseases of Tomato in Field and High Tunnels. *In* Proceedings of the Upper Midwest Regional Fruit and Vegetable Growers Conference, Jan. 19-20, St. Cloud, MN.

Local and State Presentations

	Date	*Presentation title, e*vent, and location
	2016	
1.	Jan 26	***Updates on cucurbit downy mildew and tomato and potato late blight.*** Wisconsin Fresh Market Growers Association Conference. Wisconsin Dells, WI.
	2015	
2.	Mar 27	***Process and utility of tomato grafting.*** Veggie School. Wisconsin Fresh Vegetable Growers Association. Hancock Agricultural Research Station. Hancock, WI.
3.	Mar 6	***Squash and tomato disease updates***. Green Lake County University of Wisconsin Extension. Dalton, WI.
	2014	
4.	Jan 21	***Leaf mold in high tunnel tomatoes and grower survey***. Wisconsin Fresh Fruit & Vegetable Growers Conference. Wisconsin Dells, WI.
5.	Jan 21	***Tomato disease control in high tunnels***. Wisconsin Fresh Fruit & Vegetable Growers Conference. Wisconsin Dells, WI.
6.	Jan 20	***Distribution and Character of Cucurbit Downy Mildew & Tomato and Potato Late Blight in 2013 – Projections for 2014.*** Wisconsin Fresh Fruit & Vegetable Growers Conference. Wisconsin Dells, WI.
7.	Jan 16	***Distribution and Character of Cucurbit Downy Mildew & Tomato and Potato Late Blight in 2013 – Projections for 2014.*** Wisconsin Crop Management Conference. Alliant Energy Center. Madison, WI.
	2013	
8.	Apr 18	***Integrated management of common tomato diseases in the high tunnel***. Wisconsin Fresh Market Vegetable Growers Association & University of Wisconsin Extension. Spring Field Day Workshop. Jack's Fresh Produce, Hancock, WI.

IV. Beneficiaries

This project directly benefited producers of high tunnel tomatoes in the state of Wisconsin and throughout the Upper Midwestern production region. Increasing the pest management and product quality of WI tomato production improved competitiveness in the marketplace and value in the fresh market sectors. WI tomato growers were direct beneficiaries through improved pest and disease management with decreased cost of pesticides.

Nearly all WI tomato-producing farms and allied industries benefited from our work. At a spring high tunnel tomato meeting, we had 80 producers in attendance with active high tunnel systems or interest in raising tomatoes in high tunnels.

This project enhanced the financial stability and future growth of the WI high tunnel tomato industry. Farm gate value of tomato is hard to assess in WI, but high tunnel season extension results in approximately 2X the total yield per plant when compared to open-field tomato production. Additionally, the average price per pound of fresh market tomatoes, regardless of production system, is $1.50-$2.50. Tomatoes grown prior to and after field season can garner ≥$2.50/lb on average, with highest citations at $4.00/lb for select specialty tomatoes. High

tunnels provide glasshouse conditions for enhanced tomato production but at a fraction of the cost allowing for increase return on investment in the short term.

V. Lessons Learned

Our initial intent was to evaluate and develop a system-wide management scheme for tomatoes grown in high tunnels in Wisconsin. After our initial year, we recognized the magnitude of this intent and the impossibility of addressing it in totality. We focused our efforts around an industry survey and disease detection and management – which best suited my program lead and staff interest. Further, this approach allowed for close engagement with other UWEX programs to further our reach in impacting growers.

VI. Additional Information

Additional content pertinent to this tomato project includes:

The University of Wisconsin-Madison/UWEX Vegetable Pathology website houses information within a separate crop tab on tomato production and disease management (http://www.plantpath.wisc.edu/wivegdis/).

The University of Wisconsin-Madison/UWEX A3422 Commercial Vegetable Production Guide includes a tomato management section of the publication. This management guide is available for free online as a pdf or for approximately $10/book in hard copy (http://learningstore.uwex.edu/Assets/pdfs/A3422.pdf).

VII. Contact Info

Amanda Gevens
Professor of Plant Pathology
University of Wisconsin - Madison
689 Russell Laboratories
1630 Linden Dr
Madison, WI 53706
(608) 890-3072
gevens@wisc.edu

7) Improving fresh market potato varieties (FY13-007)

Report Date: September 19, 2016

I. Project Summary

Potatoes are the most valuable horticultural crop in Wisconsin, with an estimated farm gate value of $256 million in 2012, and approximately 50% of the crop is sold into the fresh market. Within the fresh market sector, the primary categories are russets and reds, with a smaller emphasis on yellow, round white, and specialty potatoes. The current market-leading varieties in these categories have well-known deficiencies, such as rough shape (Russet Burbank), poor expression of potato virus Y (Silverton), susceptibility to Verticillium wilt (Russet Norkotah), loss of skin color in storage (Red Norland), and susceptibility to common scab (Yukon Gold). Because of a historical legacy to breed for chip processing quality in the University of Wisconsin breeding program, as well as coordinated research efforts on a national level for processing markets, the intensity and sophistication of new variety development for the fresh market has been somewhat underdeveloped in Wisconsin relative to its market share. This proposal was designed to expand the UW fresh market variety development program.

B. Recognizing that variety development takes many years, this project built on a 2012 SCBG with the same title and added two more objectives.

II. Project Approach

There were six objectives for this grant.

Objective 1. Identify new varieties with production and market potential in Wisconsin.
Approximately 150 fresh market potato breeding lines were evaluated in the 2012 project. Based on those results, the most promising lines were selected to be evaluated in the current project. Trials were conducted for the three primary major fresh market types: reds (standard was Dark Red Norland), yellows (standards were Yukon Gold, Gala, and Soraya), and russets (standards were Russet Norkotah, Silverton, and Goldrush). For each category, one research farm was paired with two commercial locations to ensure the results were representative of the diverse Wisconsin production environments (see Table 1). Thus every breeding line was tested in 3 locations, using three replicates per location and 15 plants per plot. The field trials were planted April - May 2014 and harvested Sept.–Oct. 2014.

Table 1. Field trials in 2014.

Market type	Standard(s)	No. entries	Locations (Organization)
Russet	Russet Norkotah Silverton Goldrush	18	Hancock (UW Research Station) Coloma (Coloma Farms) Nekoosa (RPE)
Red	Dark Red Norland	14	Antigo (Langlade Co. Research Station) Endeavor (Gumz Muck Farms) Bancroft (RPE)
Yellow	Yukon Gold Gala Soraya	7	Hancock (UW Research Station) Arena (Alsum Produce) Ellis (RPE)

Tables 2–4 present the three-location averages for yield (total, A-size, and B-size) and cull percentage, grouped by vine maturity. For the reds, only two other breeding lines appeared to mature at the same time as the standard Dark Red Norland, but neither was competitive in terms of A-size yield. For the later maturity group, high yields were observed for both W6002-1R and W8405-1R. The former was released by the UW breeding program as Red Endeavor in 2014. In the yellow category, none of the breeding lines showed early vine maturity like the standard Yukon Gold, illustrating that a gap exists in terms of breeding for the early yellow market. The top-yielding line in the trial was W9576-11Y. For the russets, a number of new varieties were competitive with the standards. Two stand-out new varieties, both in terms of yield and appearance, were CW08071-2 and CW08221-5. All of these varieties were exhibited for the potato industry to review at the Hancock Research Station Variety Expo, held Oct. 29–30, 2014 (Figure 1).

Table 2. Yield results for red varieties.

Name	Maturity	Total Yield (cwt/a)	A size (cwt/a)	B size (cwt/a)	Cull %
Dark Red Norland	Early-Mid	361	276	53	7
W8893-1R	Early-Mid	285	14	76	14
W8886-3R	Early-Mid	274	123	78	16
W6002-1R	Mid-Late	415	305	77	5
MN10003PLWR-02R	Mid-Late	285	88	114	10
VW08049-1R	Mid-Late	326	183	105	5
W8890-1R	Mid-Late	332	212	77	6
W9426-3R	Mid-Late	325	75	141	8
CO05228-4R	Mid-Late	308	85	143	4
MN10003PLWR-06R	Mid-Late	330	194	90	7
W8405-1R	Mid-Late	409	270	87	9

Table 3. Yield results for yellow varieties.

Name	Maturity	Total Yield (cwt/a)	A size (cwt/a)	B size (cwt/a)	Cull %
Yukon Gold	Early	333	294	23	8.4
Gala	Mid	457	343	100	2.8
NW64-4	Mid	455	353	92	6.0
NW64-6	Mid	442	311	110	4.9
Soraya	Mid	501	366	115	3.6
W9576-11Y	Mid	564	495	54	10.3
W9576-13Y	Mid	404	307	82	7.9
W6703-1Y	Late	437	373	46	4.0
NW55-6	Late	450	304	122	0.4
W9577-6Y	Late	541	452	70	12.6

Table 4. Yield results for russet varieties.

Name	Maturity	Total Yield (cwt/a)	> 4 oz. (cwt/a)	< 4 oz. (cwt/a)	Cull %
Goldrush	Early-Mid	526	414	65	3
Russet Norkotah	Early-Mid	442	341	58	3
AFW5086-1	Early-Mid	487	364	24	6
W8516-1rus	Early-Mid	552	491	28	2
W9133-1rus	Early-Mid	580	454	33	5
A02507-2LB	Mid-Late	528	433	43	3
A061006-1CR	Mid-Late	684	530	80	3
A99029-3E	Mid-Late	590	480	76	2
AFW5060-5	Mid-Late	609	502	55	3
AW07049-2	Mid-Late	536	427	70	2
AW07791-2	Mid-Late	694	558	50	4
AW07978-2	Mid-Late	589	462	29	5
CO05175-1RU	Mid-Late	610	468	39	5
CW08071-2	Mid-Late	767	634	63	3
CW08221-5	Mid-Late	707	610	50	2
Silverton	Mid-Late	613	491	19	5
W9433-1rus	Mid-Late	514	404	17	7
W9492-4rus	Mid-Late	719	490	126	5
W9519-3rus	Mid-Late	586	473	32	4
W9759-1rus	Mid-Late	511	381	77	3
W9939-8rus	Mid-Late	523	376	91	4

Figure 1. 2014 Variety Expo at the Hancock Agricultural Research Station.

Objective 2. Screen potential varieties for improved culinary characteristics.
Based on the results from the agronomic trials, a subset of the most promising varieties in the red and russet market categories were selected for human sensory evaluation in May 2016. For russets, six advanced selections (AFW5472-1rus, CW08071-2rus, CW08221-5rus, W9133-1rus, W9433-1rus, W9519-3rus) were tested along with the check varieties Goldrush, Russet Norkotah, and Silverton. In the red category, six advanced selections (W8890-1R, W8893-1R, W8405-1R, W6511-1R, W10114-3R, W10209-2R) and one recently named variety (Red Endeavor) were compared with the established varieties Dark Red Norland and Red LaSoda.

The experimental design involved 12 human subjects, who were presented with two consecutive trios of baked potato samples (in small cups). The incomplete block design was balanced with respect to both subject and trio. Subjects were asked to graphically score each of the three samples in the trio by marking their relative position on a number line, with respect to mealiness, sweetness, bitterness, and overall acceptability.

Table 5. F-test results from the human sensory evaluation, for the significance of variety for four culinary attributes.

	Mealiness	Sweetness	Bitterness	Overall
Red	3.0*	4.2***	3.0*	1.4
Russet	2.8*	1.1	2.4*	1.0

* = 0.01 < p < 0.05
** = 0.001 < p < 0.01
*** = p < 0.001

Table 5 shows the results from an analysis of variance of the human sensory data. The F-statistic measures the genetic effect relative to the residual variance and is used to determine whether there is a significant effect of variety. Mild statistical significance ($0.01 < p < 0.05$) was detected for mealiness and bitterness in both market categories, but this did not appear to affect the overall acceptability, for which there were no significant differences between the new varieties from the UW program and the market standards. Only one trait showed strong evidence of genetic differentiation: sweetness in the red category. Table 6 shows the average sweetness score (in arbitrary units) for the 9 red varieties in the test, with a higher number indicating greater sweetness. Except for W8890-1R, which was the sweetest entry in the trial, the advanced selections spanned the same approximate range as the three market standards. Certified minitubers of W8890-1R were produced in 2016 and will be available for FY1 seed production in 2017.

Table 6. Sweetness results (in arbitrary units) for red varieties.

Name	Sweetness
W8405-1R	3.6
Red LaSoda	3.9
W6511-1R	3.9
Red Endeavor	4.0
W10114-3R	4.1
W10209-2R	4.4
Dark Red Norland	5.6
W8893-1R	6.0
W8890-1R	8.5

For many of these varieties, this was the second year of human sensory evaluation; the research in 2015 was supported by an FY12 SCBG. In 2015, no significant differences in sweetness were observed, but there was a highly significant difference in mealiness for the reds. When compared to the 2016 results, the relative ranking of the varieties for mealiness was very different, indicating there are genotype x environment interactions for culinary traits. For example, W8405-1R received the highest mealiness score in 2015 but was rated second lowest for mealiness in 2016.

Objective 3. Screen varieties for resistance to key potato diseases.

Disease resistance was scored after harvest (October 2014) as the percentage of tubers from a 15-tuber sample per plot that showed symptoms of the disease (i.e., disease incidence). The three primary diseases we studied were silver scurf, black scurf, and common scab, all of which have the potential to reduce the marketability of potatoes. We also screened for early and late blight but did not observe these diseases. Using a generalized linear random effects model (SAS PROC GLIMMIX), we found that most of the observed variation was due to the environment rather than genetics. This is quantified by the ratio between the genetic and environmental variances (Vg/Ve), which is reported in Table 7.

Table 7. Heritability results (Vg/Ve) for disease resistance

Disease	Red	Russet
Silver Scurf	0.15	0.04
Black Scurf	0	0.68
Common Scab	0.12	0.09

Objective 4. Produce virus-free seed for varieties with fresh market potential.

Before new potato varieties can be commercialized, certified seed must be produced from the breeder's seed. For the UW breeding program, breeder's seed refers to tubers propagated at the Rhinelander Agricultural Research Station since the breeding line was created from true seed. Typically 6–7 years of propagation on the breeding farm has occurred before a decision is made to produce certified seed. The first step of that process, known as virus eradication, involves initiating the breeding line into tissue culture and curing in vitro plantlets of disease through a combination of chemical and heat treatments. Once virus-free plantlets have been generated, which typically takes one year, certified minitubers are produced in greenhouses at the UW Lelah Starks Seed Farm.

This project has supported the successful eradication of virus from three new potential fresh market russet varieties: W9850-5rus, CW08221-5rus, and CW08071-2rus. All three lines will be reviewed by the SpudPro variety development committee of the Wisconsin Potato and Vegetable Growers Association at the next meeting (Nov. 2016) to decide which should enter the seed certification program in 2017.

A new group of fresh market varieties was initiated into tissue culture in March 2016. Three red varieties (W6511-1R, W10114-3R, W10209-2R) and one yellow variety (W10564-19Y) have completed the first round of antiviral treatment and are expected to be certified virus-free in early 2017.

Objective 5. Determine optimal nitrogen and water management for new varieties.

Two fresh market russet potato breeding lines with commercial potential (W9133-1 and W9433-1) were evaluated in nitrogen rate and deficit irrigation trials at the UW Hancock Research Station in 2014. Four different levels of nitrogen fertilization were tested, with three replicates per treatment and 20 ft. single-row plots. N rate did not lead to significant changes in yield or tuber size distribution (Table 8), which is consistent with previous research on chip processing varieties.

Table 8. Results from the nitrogen rate trial.

			Size Distribution (% by oz.)						
Variety	N rate (lb/A)	Total Yield (cwt/a)	2-4	4-6	6-8	8-10	10-13	13-16	>16
	180	736.3	3.7	9.0	12.5	11.7	17.5	13.3	32.3
	230	735.6	2.9	7.7	9.5	12.4	17.1	11.9	38.5
	280	754.1	2.9	6.9	9.3	10.0	17.0	15.0	38.9
	330	749.1	2.8	6.4	8.1	10.2	15.5	14.9	42.1
LSD (*P*=0.05)		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Russet Norkotah		885.8	4.44	11.6	14.0	16.2	18.2	12.8	22.8

W9133-1rus	609.5	3.37	8.0	10.6	10.1	19.4	14.4	34.1
W9433-1rus	736.1	1.45	2.9	5.0	6.9	12.8	14.2	56.9
LSD (*P*=0.05)	**58.1**	**0.97**	**2.5**	**2.7**	**3.0**	**3.4**	**NS**	**6.2**

NS = not significant
LSD = Fisher's Least Significant Difference

For the water management trial, the normal irrigation schedule was calculated to meet 100% evapotranspiration (ET), and the deficit irrigation treatment was for 75% ET. The timing of all irrigation events was the same for both treatments, but the amount of water applied was reduced. Four replicates were planted, with two-row plots 15 ft. in length. The results, shown in Table 7, indicate that the size profile of W9133-1 was significantly smaller under the reduced irrigation treatment. Under normal irrigation, 36% of the harvest was over 16 oz, while at 75% ET only 21% of the yield was over 16 oz. Deficit irrigation had no significant impact on the size profile of W9433-1.

Table 9. Results from the deficit irrigation trial.

			Size Distribution (% by oz.)						
Variety	Irrigation	Total Yield (cwt/a)	2-4	4-6	6-8	8-10	10-13	13-16	>16
	Normal	641.2	5.9	11.9	14.2	14.4	18.4	13.3	21.9
	Deficit	621.6	5.5	11.1	14.3	14.2	19.1	13.8	21.9
LSD (*P*=0.05)		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Burbank		645.0	8.3	18.6	19.7	16.4	20.1	7.4	9.6
Goldrush		587.2	7.8	11.9	16.4	16.8	18.7	12.2	16.3
W9133-1rus		665.7	4.3	7.2	9.7	12.4	21.0	16.9	28.4
W9433-1rus		655.7	1.2	3.3	6.5	5.2	14.3	20.0	49.5
Russet Norkotah		727.4	3.7	8.7	12.7	15.0	18.8	13.4	27.7
Silverton		544.9	3.9	10.6	15.2	13.9	20.3	14.8	21.3
LSD (*P*=0.05)		**52.5**	**1.4**	**2.4**	**2.5**	**2.6**	**2.8**	**3.7**	**4.7**
Burbank	Normal	648.4	10.4	21.2	20.1	17.9	18.1	6.9	5.4
Burbank	Deficit	641.6	6.3	16.0	19.3	14.9	22.1	7.9	13.8
Goldrush	Normal	643.0	7.0	12.5	17.1	16.5	18.5	13.0	15.6
Goldrush	Deficit	531.4	8.6	11.3	15.7	17.2	19.0	11.4	17.1
W9133-1rus	Normal	711.1	3.9	6.4	10.6	10.9	14.7	17.6	36.0
W9133-1rus	Deficit	620.3	4.8	8.1	8.8	14.0	27.4	16.2	20.9
W9433-1rus	Normal	648.1	0.9	2.0	6.2	7.2	16.4	16.7	50.6
W9433-1rus	Deficit	663.4	1.6	4.6	6.9	3.2	12.3	23.3	48.4
Russet Norkotah	Normal	749.7	3.3	8.0	13.7	15.6	21.1	13.3	25.1
Russet Norkotah	Deficit	705.2	4.2	9.5	11.7	14.5	16.5	13.5	30.3
Silverton	Normal	553.9	4.4	10.1	12.8	13.5	20.7	16.3	22.2
Silverton	Deficit	535.9	3.5	11.1	17.7	14.3	20.0	13.3	20.4
LSD (*P*=0.05)		**NS**	**2.0**	**3.4**	**NS**	**NS**	**3.9**	**NS**	**6.6**

Objective 6. Predict value of new varieties to growers and packing sheds.
Shipping point average prices for russet potatoes in Central Wisconsin were downloaded from the USDA website (http://cat.marketnews.usda.gov/cat/?shortcut=shippingPoint). A three-year average from 2011–2013 was used to compute gross returns for the yields reported in Table 4, using sizes 40ct through 100ct and Strips. The economic results, shown in Table 10, closely mirror the yield rankings. In the early-mid maturity category, W8516-1rus had the highest estimated value, but the estimate was not significantly higher than either of the standards, Goldrush and Russet Norkotah. There were also no significant differences between varieties in the mid-late category.

Table 10. Gross returns for new russet varieties.

Name	Maturity	Gross Return per acre
W8516-1rus	Early-Mid	$10,500
W9133-1rus	Early-Mid	$9,940
Goldrush	Early-Mid	$8,220
AFW5086-1	Early-Mid	$7,810
Russet Norkotah	Early-Mid	$6,890
CW08071-2	Mid-Late	$12,790
CW08221-5	Mid-Late	$12,600
AW07791-2	Mid-Late	$11,570
Silverton	Mid-Late	$10,880
A061006-1CR	Mid-Late	$10,250
AFW5060-5	Mid-Late	$10,100
W9519-3rus	Mid-Late	$10,100
CO05175-1RU	Mid-Late	$9,810
A99029-3E	Mid-Late	$9,590
AW07978-2	Mid-Late	$9,390
W9492-4rus	Mid-Late	$9,300
W9433-1rus	Mid-Late	$8,800
A02507-2LB	Mid-Late	$8,760
AW07049-2	Mid-Late	$8,220
W9759-1rus	Mid-Late	$7,390
W9939-8rus	Mid-Late	$6,730

III. Goals and Outcomes Achieved

The overarching goal of this project was to facilitate commercialization of new fresh market varieties. This is a lengthy process but significant, measurable progress was made during this project. Based on small plot agronomic trials, disease and culinary tests, three new russet varieties completed the virus eradication process, which is the first step toward making certified seed available to growers. Four additional varieties are currently half-way through this process. In parallel, additional data was collected to support the continued increase of certified seed for two red (W8893-1R, W8890-1R), two russet (W9133-1rus, W9433-1rus), and one yellow (W9576-11Y) variety. Four commercial growers tested one or more of these lines at the half-acre

scale in 2016 using breeder's seed, which will help drive demand for the certified seed when it becomes available.

B. Endelman did not submit the proposal for this project; he became PI when the original project lead left UW-Madison in early 2014. In the proposal, the goal was to produce certified seed for 20 varieties, which may have been possible if the breeding programs from other states had allowed Wisconsin to initiate commercialization of out-of-state varieties. However, there is no tradition of this occurring (for legal and economic reasons), and no commitments were secured from other breeders. Thus, Endelman focused on commercializing varieties from the UW-Madison program, for which this goal was not realistic because in any given year no single breeding program in the U.S. produces that many varieties with commercial potential. Due to the complex tetraploid genetic structure of potato, the odds of identifying a new variety with commercial potential are approximately 1 in 10,000.

IV. Beneficiaries

The primary beneficiary of this research is the Wisconsin fresh market potato industry. New varieties from this project have the potential to increase marketable yield, reduce post-harvest losses, or increase the competitiveness of Wisconsin growers in the US market. The potential economic impact to the WI potato industry is difficult to quantify, but the farm-gate value of the Wisconsin fresh market crop is over $100 million annually. Results from this project, and more generally the suitability of new varieties for production in Wisconsin, were presented to potato growers at several meetings and field days, as listed in Table 11.

Table 11. Outreach presentations related to this project.

Date	Location	# of Attendees
July 28, 2016	UW Hancock Agricultural Research Station Field Day	120
July 21, 2016	Langlade County Agricultural Research Station Field Day	50
July 14, 2016	UW Rhinelander Agricultural Research Station Field Day	35
Feb. 4, 2016	WPVGA Grower Education Conference (Stevens Point)	100
Feb. 3, 2016	WPVGA Grower Education Conference (Stevens Point)	30
Jan. 28, 2016	WI Seed Potato Improvement Association Annual Meeting (Antigo)	75

V. Lessons Learned

The results related to disease resistance in Objective 3 were unexpected and disappointing. The disease incidence results for silver scurf and common scab, which are ubiquitous in WI environments and can dramatically reduce the marketability of potatoes, indicate that most of the variation was environmental and not genetic. This suggests there is limited opportunity to make progress through breeding using our current elite germplasm.

VI. Additional Information

None

VII. Contact Info

Jeff Endelman
Professor of Horticulture
University of Wisconsin - Madison
327 Moore Hall-Plant Sciences
1575 Linden Dr
Madison, WI 53706
(608) 250-0754
endelman@wisc.edu

8) Improving food safety practices for fresh market fruit and vegetable producers in Wisconsin (FY13-008)

Report Date: October 31, 2016

I. Project Summary

Over 80,000 acres of fresh market vegetables, tree fruit and berries are produced in Wisconsin according to the United States Department of Agricultures (USDA) Census of Agriculture. Many smaller acreages go unreported. This production takes place primarily on small farms that sell their produce directly to the public and/or wholesale to grocery stores, restaurants, and schools. In addition to being growers, handlers, shippers, marketers, and sellers of produce, they have recently become expected to mitigate the risk of food borne illness.

According the Center for Disease Control (CDC), food borne illness impacts 48 million Americans each year and costs the economy an estimated $6.7 billion. The majority of these losses have been attributed to fresh fruits and vegetable consumption. To reduce the risk of food contamination, many farms have instituted a collection of principles outlined by the USDA. These principles, called Good Agricultural Practices (GAP) and Good Handling Practices (GHP), apply to on-farm production and post-production processes.

Although these principles exist, many small fruit and vegetable growers have not moved toward implementation. After several workshops and conferences for these groups that have provided educational sessions about GAP and GHP, many farmers have come away with the belief that it is too expensive, too time consuming, and too complicated to institute these practices. Many farmers have taken an “all or nothing” approach to on farm food safety.

In addition to GAP and GHP food safety expectations, Food Safety Modernization Act legislation to further develop standards for the growing, harvesting, packing, and holding of produce for human consumption was pending. The USDA’s Food Safety Modernization Act (FSMA), which was in its first comment period, would have applied to farms selling more than $25,000 a year in produce, unless the majority of that produce was sold directly to the consumer or to a qualified restaurant or food establishment. It was believed that unless farmers move toward compliance and eventually pass a GAP/GHP food safety audit, small farms would be unable to grow and diversify.

The project outlined in this grant focused on presenting GAP and GHP in a manner farmers find approachable and attainable. Once farmers believe they could improve food safety with a limited commitment of time and assets, it was hoped that they would be more willing to identify areas of improvement on their farms. Over time, these changes would have the effect of not only improving food safety, but also build the farmers capacity to pass a food safety audit when and if it was needed.

The more Wisconsin farms that improve food safety by adopting GAP and GHP principles, the greater the reduction in food safety risk, not only to the individual farm, but also to the fruit and

vegetable industry in the state. A foodborne illness outbreak would be devastating not only to the fresh market farm originating the outbreak, but to all fresh market growers. Educating farmers to mitigate the risk of food borne illness was intended to not only keep the general public safe, but also help to protect the financial future of small fruit and vegetable farms in Wisconsin.

II. Project Approach

November 2013 – March 2014

- Host three food safety educational workshops in Wisconsin (Stevens Point, Wisconsin Dells and Milwaukee areas).

Three food safety educational workshops were held in Wisconsin. The first was held in conjunction with the Wisconsin Fresh Fruit and Vegetable Growers Conference (WFFVGC) in Wisconsin Dells on January 19, 2014 with 24 attendees. The Stevens Point workshop was held in cooperation with Ken Schroeder, Agriculture Agent for UW-Extension Portage County on February 7, 2014 with 13 attendees. The third workshop was held On February 8, 2014 in Elkhorn, Wisconsin in cooperation with Peg Reedy, Agriculture Agent for Walworth County UW-Extension and Rose Skora, Agriculture Educator for UW-Extension in Racine and Kenosha Counties with 53 attendees.

Each of the three workshops featured Chris Blanchard of Rock Spring Farm and Flying Rutabaga Works. Chris spoke to the audience of his firsthand knowledge of safe food production and handling practices. Surveys were administered to measure the increase in knowledge of workshop participants in the area of food safety. The survey was not administered at the WFFVGC due to a logistical oversight, however the average increase in food safety knowledge for the other two locations was 56% (n=42). This increase in knowledge exceeded the target of 35%.

In addition to measuring the increase in knowledge of participants, each farm business was asked to complete a six-page food safety survey. The goal of this survey was to assess the on farm practices related to food safety currently being used by Wisconsin fruit and vegetable growers. This information is currently being used to identify areas where “best practices” can be developed for on farm processes that may contribute to poor food safety practices. Areas currently being explored include safe manure composting practices, safe produce harvesting, safe produce storage techniques, and cleaning and sanitizing produce washing equipment.

December 2014 – April 2015

- Assist farmers in identifying areas for food safety improvement and implementation

During this grant reporting period, four workshops were given by Dr. Silva that helped identify food safety issues, areas of improvement, and suggestions for implementation (see below table). Additionally, Dr. Silva responded to approximately 20 farmer emails and phone calls with specific questions about food safety implementation.

Date	# attendees	Venue and Location	Presentation Title
January 26	75	Wisconsin Fresh Fruit and Vegetable Conference, Wisconsin Dells, WI	Food Safety Update for Apple Growers
January 27	50	Wisconsin Fresh Fruit and Vegetable Conference, Wisconsin Dells, WI	Food Safety Update for Vegetable Growers
February 17	20	Vegetable Workshop, Elkhorn, WI	Food Safety Update for Vegetable Growers
March 5	20	Vegetable Workshop, Thorp, WI	Food Safety Update for Vegetable Growers

The number of participants at each location permitted an informal evaluation. Groups were asked for immediate feedback at the end of the workshop. At the Thorp location, attendees said the information was valuable and encouraged UW-Extension to continue to update GAP education. In Elkhorn, attendees said that they had learned a lot, but the lack of certainty about the FSMA was a concern. Both groups desired continued updates on FSMA next year if the rules were passed. The survey of the attendees at the Wisconsin Fresh Fruit and Vegetable Growers Conference were collected by the conference conveners. No comments were collected but the presentations were rated as 3.9 for the Apple growers and 3.7 for vegetable growers on a 5-point scale.

May 2015 – November 2015

- Implement food safety website and linkages to other relevant sites and resources

During this grant period, Dr. Silva continued to coordinate and execute meetings of a food safety working group. This group consists of representatives from DATCP (Steve Ingham, Theresa Engel, and Angie Sullivan), UW-Extension (Kristin Krokowski), industry and food hubs (Organic Valley Produce Pool, So. WI Food Hub, Green Bay Food Hub), and non-profit educators (Harriet Behar, MOSES and Chris Blanchard, Purple Pitchfork and contracting for UW-Extension). Others are involved if interested and if other expertise is needed, including Don Stoeckel. This group meets quarterly, regularly discussing the status of and emerging issues resulting from GAP certification, food safety audits, and the Food Safety Modernization Act (FSMA), emerging. With assistance and collaboration from this group, communication within key state groups as to existing priorities and emerging food safety needs has been enhanced.
To gain more knowledge of the common potential areas of contamination and the FSMA, and to extend the knowledge base of the Wisconsin Food Safety work group, Anne Pfeiffer and Kristin Krokowski attended the Produce Safety Alliances Train the Trainer Workshop held in Kalamazoo, MI. This workshop not only enabled these two educators to become certified trainers (pending) for the produce safety rule, but also imparted a much deeper sense of what FSMA is and where the stumbling blocks might be for produce growers. As a result of this training, the areas most challenging or ambiguous to growers were identified. This information was used to develop videos and resource materials for growers that can be used to refresh or

develop the farmer's knowledge of good agricultural practices. The two areas of focus were identified as water testing and wildlife management.

A website was created, jointly promoted by UW-Extension and DATCP. This website provides relevant food safety sites housed at other land-grant University and reputable food safety training center websites. Over 300 people have accessed the website over the last 6 months. The website can be accessed at: http://labs.russell.wisc.edu/farmfoodsafety/.

- Identify priority or emerging food safety needs, identify speakers and schedule webinars

Two recorded food safety webinars were planned. One was recorded in November of 2015 as part of UW-Extension Wisconsin Public television series, University Place. This webinar has been aired on Wisconsin Public Television and can be accessed at http://wpt.org/University-Place/understanding-farm-food-safety. Approximately 60 extension educators were present at the time of filming. A second food safety webinar was scheduled on a platform with national reach, eOrganic. This webinar, co-presented by Erin Silva and Don Stoeckel, was scheduled for March 2016.

December 2015 – March 2016

- Hold and evaluate webinar series.

The webinar (described above) was held in late March and aired over the eOrganic platform to a national audience. Over 200 people attended the live webinar and over 300 have viewed the archived version; which can be accessed here: https://www.youtube.com/watch?v=zOGqJJcxNlE.

Additionally, the following face-to-face meetings were conducted in this timeframe:

Date	**# attendees**	**Venue and Location**	**Presentation Title**
November 19	50	Organic Valley Produce Pool Meeting, La Farge, WI	On-Farm Food Safety
January 25	50	Wisconsin Fresh Fruit and Vegetable Conference, Wisconsin Dells WI	Food Safety Modernization Act Update
January 28	100	Amish Grower Meeting, Dalton, WI	Food Safety Training
March 10	10	Grant County Food Safety Meeting	Food Safety for Diversified Vegetable Farmers
March 15	30	Portage County Food Safety Meeting	Food Safety for Diversified Vegetable Farmers
March 18	30	Vernon County Food Safety Meeting	Food Safety for Diversified Vegetable Farmers
March 30	20	Richland County Food Safety Meeting	Food Safety for Diversified Vegetable Farmers

April 2016 – August 2016

- Update food safety website information.

The food safety website continues to be updated as new materials are generated. Video needs identified the previous summer in the areas of water and wildlife management were scripted, recorded and edited for posting on the food safety website.

University of Wisconsin Extension Specialists were recruited to lend their expertise to these safety videos. Dr. Kevin Masarik, Groundwater Educator at the University of Wisconsin in Stevens Point served as the expert in two videos, one on the reasons to test your ground water and the other on collecting a good water sample. Dr. David Drake, University of Wisconsin Madison based UW-Extension Specialist served as the expert for videos focusing on managing rodents in the barn and mitigating wildlife in the field. These videos are in the final stages of editing and will soon be posted on the food safety website.

- Identify unmet and future food safety needs.

The food safety working group continues to meet on a quarterly basis to identify unmet and future food safety needs. Many of these needs center on the implementation of the Food Safety Modernization Act. Federal and state movement on this regulation has been slow; however, this will continue to be a primary food safety need in the near future.

Specific groups involved:

- Organic Valley/CROPP cooperative produce pool
- Winnebago County Food Hub
- So. Wisconsin Food Hub
- Amish and Mennonite produce auctions across WI (Tri-County produce auction, Cashton produce auction)
- Wisconsin Fresh Fruit and Vegetable Association
- Midwest Organic and Sustainable Education Services
- FamilyFarmed.org
- Produce Safety Alliance

III. Goals and Outcomes Achieved

2015

- Four educational sessions were held for a total of 165 participants on Good Agricultural Practices and Good Handling Practices related to on farm food safety.
- Four food safety working group meetings were held to inform the overall status direction and implementation of the Food Safety Modernization Act in Wisconsin. A list of participating organizations is listed above.
- Dr. Silva responded to approximately 20 farmer emails and phone calls with specific questions about food safety implementation.

- Attended the Produce Safety Alliances Train the Trainer Workshop held in Kalamazoo, MI. This workshop enabled these two educators to become certified trainers (pending) for the produce safety rule.

2016

- Seven educational sessions were held for a total of 165 participants on Good Agricultural Practices and Good Handling Practices related to on farm food safety.
- Four food safety working group meetings were held to inform the overall status direction and implementation of the Food Safety Modernization Act in Wisconsin
- Two recorded food safety webinars were conducted. One titled "Understanding Food Safety" and the second "Food Safety". Approximately 60 extension educators were present at the time of filming the first webinar. The number of viewings from the archived version is not available. The second food safety webinar scheduled on a platform with national reach, eOrganic, was attended by over 200 people and over 300 have viewed the archived version.
- Four educational videos were scripted, recorded and edited for posting (reasons to test your ground water, collecting a good water sample, managing rodents in the barn, and mitigating wildlife in the field) for posting on the food safety website

B. **Outcome 1:** Increase knowledge of fruit and vegetable growers about the most common avenues of on farm food contamination and ways to avoid food borne illness.

The increase in knowledge of this outcome will be measured through a written evaluation where farmers rate their level of knowledge before and after attending the food safety workshop. The goal increase in knowledge is 35%. If that benchmark is not attained, educators will discuss modifying the presentations for subsequent workshops to achieve this goal.

Year	# attendees	Venue and Location	Presentation Title
January 26, 2015	75	Wisconsin Fresh Fruit and Vegetable Conference, Wisconsin Dells, WI	Food Safety Update for Apple Growers
January 27, 2015	50	Wisconsin Fresh Fruit and Vegetable Conference, Wisconsin Dells, WI	Food Safety Update for Vegetable Growers
February 17, 2015	20	Vegetable Workshop, Elkhorn, WI	Food Safety Update for Vegetable Growers
March 5, 2015	20	Vegetable Workshop, Thorp, WI	Food Safety Update for Vegetable Growers
November 19, 2016	50	Organic Valley Produce Pool Meeting, La Farge, WI	On-Farm Food Safety
January 25, 2016	50	Wisconsin Fresh Fruit and Vegetable Conference, Wisconsin Dells WI	Food Safety Modernization Act Update

January 28, 2016	100	Amish Grower Meeting, Dalton, WI	Food Safety Training
March 10, 2016	10	Grant County Food Safety Meeting	Food Safety for Diversified Vegetable Farmers
March 15, 2016	30	Portage County Food Safety Meeting	Food Safety for Diversified Vegetable Farmers
March 18, 2016	30	Vernon County Food Safety Meeting	Food Safety for Diversified Vegetable Farmers
March 30, 2016	20	Richland County Food Safety Meeting	Food Safety for Diversified Vegetable Farmers

Surveys were administered in year one of the grant to measure the increase in knowledge of workshop participants in the area of food safety. The survey was not administered at the WFFVGC due to a logistical oversight, however the average increase in food safety knowledge for the other two locations was 56% (n=42). This increase in knowledge exceeds the grants target of 35%.

Outcome 2: Increase the knowledge of farmers about the Food Safety Modernization act and how it applies to individual farms.

The increase in knowledge of this outcome will be measured through a written evaluation where farmers rate their level of knowledge before and after attending the food safety workshop. The goal increase in knowledge is 35%. If we do not attain that benchmark, we will discuss modifying the presentations for subsequent workshops to achieve this goal.

As part of the goal to increase farmer knowledge and provide training on the Food Safety Modernization act, the project coordinator, Kristin Krokowski, attended a FSMA train-the-trainer workshop conducted by the Produce Safety Alliance (PSA) June 2-3, 2015 in Kalamazoo, MI. This workshop was designed to train the individuals that would be certified to offer FSMA training to growers around the country. During the training, materials created by the PSA were reviewed which provided a much deeper sense of what FSMA is and where the stumbling blocks might be for produce growers. As a result of this training, the areas most challenging or ambiguous to growers were identified. This information was used to develop videos and resource materials for growers that can be used to refresh or develop the farmer's knowledge of good agricultural practice.

Because the final FSMA rule had not been passed, further train-the-trainer workshops were halted until the final rule was posted and the training materials updated to reflect the final rule. The Food Safety Modernization Act final rule was posted on November 27, 2015. Although it was monitored though both comment periods, adjustments were made to the final rule that made it necessary to seek further guidance. Parts of the rule that have caused the greatest uncertainty are water testing and soil amendments. Since guidance documents are still forthcoming from the Food and Drug Administration, trained trainers have been unable to provide training on the rule.

Updates were also necessary for the PSA's train-the-trainer manual. Once the manual was updated to reflect the changes in the final rule, they sought approval for the training materials. The training materials were approved during the summer on 2016 and the PSA held a training update for the individuals who received training prior to the update in September of 2016. As a result of these delays and the pending guidance from the FDA, no formal training on FSMA has been held. However, the infrastructure for future trainings has been created.
Outcome 3: Increase the number of farmers who evaluate their farms for potential sources of contamination by food borne illness.

During the workshops, educators will ask farmers to identify three areas of their farm that are potentially areas of food safety risk and actions that they could take to mitigate that risk. The project goal is to have 75% of those attending participate in this activity and hand in their identified risk areas and corrective actions.

The extended comment period, the changes made after the first comment period, and the delayed posting of the FSMA rule, caused farmers to be leery of making modification to improve their food safety until the final rule was passed. By delaying changes to their operations, farmers hoped to prevent incurring unnecessary effort and expense should the rule be changed. Because of this attitude, growers were unwilling to commit to making food safety changes to their operations and report back to us about it during the granting period.

Outcome 4: Identify common areas of potential on farm food contamination on small Wisconsin produce farms through mock audits.

In cooperation with the WDATCP Fruit and Vegetable Inspection Unit, UW-Extension will conduct mock audits on Wisconsin fruit and vegetable farms to evaluate the level of compliance with food safety audit specifications. The data from these mock audits will be compiled to identify the most common areas of non-compliance and evaluated for areas of greatest risk of contamination. The project benchmark is to mock audit a minimum of four farms and a maximum of six farms.

Much time was committed to identifying farms to participate in on-farm audits. In addition to workshop contacts, not for profits, grower associations, and University of Wisconsin Cooperative Extension county agriculture agents were asked to assist with recruitment. Three site were identified in 2014-2015. One reconsidered his willingness to have the audit videotaped. The second audit was cancelled by the grower early on the morning of the audit because they didn't believe that they were ready and timing of the third audit conflicted with other responsibilities of the Department of Agriculture Trade and Consumer Protections Good Agricultural Practices auditor.

Although attempts to find growers to participate continued, more were willing to allow the taping of educational videos on their farms not directly tied to an audit. In response to this the project team decided to focus on the utilizing University of Wisconsin Extension Madison based campus specialists to create educational videos about food safety related topics that would benefits a broad range of produce growers regardless of if they were subject to the rule.

Outcome 5: Prepare 4-6 web based videos identifying common areas of food contamination on the farm and how to come into compliance.

In response to the audit, the farmer will put together a plan for improvement. As the approved work is completed, the process will be filmed. This video will then be narrated and posted on the internet to help other farmers make similar improvements. A minimum of four and a maximum of six videos will be edited, narrated, and posted on a food safety website for public viewing. Early videos will be reviewed to optimize the quality and usability of the series.

The original approach to identifying common areas of food safety concern through mock audits failed. As a result, educators sought other options for determining areas that would benefit from instructional videos.

To gain more knowledge of the common potential areas of contamination and the FSMA and extend the knowledge base of the Wisconsin Food Safety work group, Anne Pfeiffer and Kristin Krokowski attended the Produce Safety Alliances Train the Trainer Workshop held in Kalamazoo, MI. This workshop not only enabled these two educators to become certified trainers (pending) for the produce safety rule but also imparted a much deeper sense of what FSMA is and where the stumbling blocks might be for produce growers. As a result of this training, the areas most challenging or ambiguous to growers were identified. This information was used to develop videos and resource materials for growers that can be used to refresh or develop the farmer's knowledge of good agricultural practices. The two areas of focus were identified as water testing and wildlife management.

University of Wisconsin Extension Specialists were recruited to lend their expertise to these safety videos. Dr. Kevin Masarik, Groundwater Educator at the University of Wisconsin in Stevens Point served as the expert in two videos, one on the reasons to test your ground water and the other on collecting a good water sample. Dr. David Drake, University of Wisconsin Madison based UW-Extension Specialist served as the expert for videos focusing on managing rodents in the barn and mitigating wildlife in the field. These videos are in the final stages of editing and will soon be posted on the food safety website.

IV. Beneficiaries

The quantitative benefits to growers that has been measured during this grant period pertains mainly to their increase in knowledge as a result of educational sessions. These measures are included above.

A broader benefit of this effort is the creation of the food safety working group. As part of this project, a group of professionals engaged in working with growers to improve produce food safety in Wisconsin was created. Although not a direct goal of this project, the group has been critical to guiding the work of this project and supporting its work. Its members represent the Wisconsin Food Hub, Organic Valley/CROPP cooperative produce pool, the University of Wisconsin Madison, Midwest Organic and Sustainable Education Services, the University of Wisconsin Cooperative Extension, and the Wisconsin Department of Agriculture, Trade and

Consumer Protection. The group has also gathered input from the following groups to guide our work:

Organic Valley/CROPP cooperative produce pool
Winnebago County Food Hub
So. Wisconsin Food Hub
Amish and Mennonite produce auctions across WI (Tri-County produce auction, Cashton produce auction)
Wisconsin Fresh Fruit and Vegetable Association
Midwest Organic and Sustainable Education Services
FamilyFarmed.org
Produce Safety Alliance

The creation of this group has led to the coordination of education and resources throughout the state as each representative brings to the meetings a different perspective and different resources. The working group has focused on being aware of the regulatory direction, educational resources to help growers with compliance, and supporting each other's understanding of FSMA and its application. This group has helped to create a source of consistent knowledge for conventional, organic, and underrepresented populations growing produce in Wisconsin. It has also helped to avoid duplication of efforts and resources.

V. Lessons Learned

Farm food safety education is not a simple topic. The evolution and institution of the Food Safety Modernization Act (FSMA) has been a long and complicated process. Although this process was grounded in creating a useful tool for the regulation of produce, it has led to great confusion and uncertainty about what the future holds for produce growers. Because the uncertain state of the rule and now the many questions that remain regarding implementation, farmers are reluctant to move forward with implementation and intimidated by complexity of the rule.

As the project team has moved through the grant timeline with this proposal, the team has needed to adjust the activities originally listed to adapt to the changing state of FSMA, changes in university staffing in the area of food safety, and changes in the perception of the rule by farmers. Much of the resulting work focused on what steps we could accomplish to orient growers to the rule by providing a broad overview of food safety and basic practices than reduce potential contamination on the farm.

Although there were many situations during the implementation of this grant that required adaptation of planned methods to achieve the listed outcomes, the outcomes were successfully addressed. Additional positive outcomes were also realized including the creation of the food safety working group and a better overall preparation of the state of Wisconsin to reduce produce related food borne illness and compliance with FSMA.

VI. Additional Information

None

VII. Contact Info

Kristin Krokowski
UW Extension Agent
UW Cooperative Extension - Waukesha County
515 Moreland Blvd. AC G22
Waukesha, WI 53188
262-548-7768
kristin.krokowski@ces.uwex.edu

9) Labor efficiency and mechanization to enhance the profitability of Wisconsin fresh market vegetable farms (FY13-009)

Report Date: October 28, 2016

I. Project Summary

A. The growing marketplace for local foods is expanding the number of small to medium scale farms across the country and in Wisconsin. These fresh market vegetable farms typically sell at farmers' markets, through community supported agriculture memberships, and to restaurants, retail stores, and institutions (including schools and hospitals). Most of these farms are highly diversified, growing as many as 40 or 50 different crops and selling via more than one marketing avenue. The resulting management complexity on these farms is extreme—from planning, production, and recordkeeping, to setting prices to analyzing financial performance.

The biggest expense on fresh market vegetable farms, like most specialty crops, is labor. Tracking labor on highly diversified farms, especially those with large or multiple work crews, is quite daunting. On any given day during the physically strenuous and mentally exhausting growing season, growers and their work crews routinely perform work on a wide variety of crops. Our team has developed some tools (paper forms and Smart-phone accessible documents) to help make the process of tracking labor by crop easier. Growers using these forms have been far more successful in recording data but they still report challenges.

To alleviate the challenge of labor data collection, our team proposed to conduct benchmarking research in order to offer an option for labor cost and crop profitability analysis. Growers could use these benchmark values based on data collected from working organic farms to perform Veggie Compass analyses while inputting their farm-specific sales and input (seeds, fertilizer, supplies, etc.) and marketing costs.

Based on previous work, labor input by crop (in terms of total labor hours per 100 row feet) varied significantly from farm to farm. It was beyond the scope of this previous work to examine why this variability exists. The research funded by this grant sought to understand and document the basis of superior efficiency of farms (in terms of labor hours) with certain crops compared to other farms.

We collected labor data on the following crops: carrots, broccoli, peppers, lettuce, and spinach. These are crops that are widely grown and have high market demand. We worked with 10 farms to collect data, recruiting farms that demonstrate the impact of different production techniques, labor management systems, and equipment. We collected data on these farms of different scales in order to capture labor data using different levels of mechanization. We analyzed the data to investigate the impact of the diversity of scales, documenting the cost and efficiency differences between doing the majority of production and harvesting work by hand or with hand tools and utilizing various types of equipment.

B. N/A

II. Project Approach

In order to conduct time studies on a diverse representation of operations, labor data were collected on ten certified organic diversified vegetable farms in Wisconsin, USA throughout two production seasons, 2014 and 2015. The farms were selected to reflect a range of production scales, levels of mechanization, and management approaches representative of upper Midwestern organic farms. This included three small farms ranging from 0 to 3 acres, four medium farms ranging from 4 to 10 acres, and three large farms ranging from 10 to 50 acres. All farms had a Community Supported Agriculture (CSA) component to their operation, but varied in the other market avenues with which they engaged.

Time and technique studies were designed to measure labor required for three specific activities: transplanting, harvest, and post-harvest handling (washing and packing). These activities were observed for five different crops: broccoli, head lettuce, carrots, bell peppers, and summer squash. Time required for the packing of CSA boxes was also measured. The observations for each activity by crop are enumerated in Table 2. As labor needs waxed and waned throughout the season, time studies were conducted when activities represented large hired labor needs within a growing season. Farmers communicated with the research team to schedule data collection for key events related to different activities. Timing of data collection was limited to fair weather conditions (e.g. no storms or extraordinary heat) in order to avoid the impact of extreme weather on labor efficiency.

To ensure farmers remained engaged in the project and the results were effectively extended, we held a series of winter meetings and summer field days. Additionally, the project was presented at several grower conferences throughout the grant period.

III. Goals and Outcomes Achieved

A. Data was collected using a cyclical measurement model, similar to the methodology used in the Department of Labor time studies. Labor inputs were recorded in 'pulses', with a pulse defined as one discreet activity for one crop (i.e. transplanting a bed of lettuce or harvesting 400 pounds of carrots). For each pulse, total time required to complete the entire pulse was recorded, as well as the time to complete shorter subsections of the pulse. Time to complete each activity was collected for every crop included in the study, plus CSA box packing. Timing of the activity began as the workers started the task (not including travel to the field or idle time).

In addition to the time for completion of each task, other production metrics were recorded, including appropriate unit of vegetable yield handled in a pulse (and in each individual trial): number of transplants and row feet for transplanting; units of vegetable harvested for harvest; units of vegetable washed and packed for post-harvest; and number of boxes packed for CSA packing. Other descriptive information on the methods (hand or machine) and techniques employed was also collected. Quantitative and qualitative characteristics with respect to the work force included crew size, experience (number of seasons employed), presence of crew leaders, presence of volunteers or CSA worker-shares, presence of farmer-owner, and the division of labor. Additional variables, including environmental conditions, market channels, were also noted. A complete list of data categories can be found in Table 3.

Interviews with the participating farmers provided supplemental information on farm management, farmer experience, crew experience, employment, wages, market channels and pricing. This information was used to provide more context for each farm when interpreting efficiencies and differences between operations.

Data was analyzed to reflect four measures of labor productivity: time per output, time per output per person, output per hour, and output per hour per person. The first two measures (time per output and time per output per person) contain the same information as the last two measures (output per hour and output per hour per person), since the measures are simply reciprocals of one another. While the participating farmers found that data summaries in the form of time per output and time per output per person were more meaningful for their decision-making processes, measurements stated as output per hour and output per hour per person are more frequently used conventional measures of labor productivity by other industries (U.S. Department of Labor, 2016).

For transplanting activities, time per 100 row feet transplanted, time per 100 row feet transplanted per person, transplants per hour, and transplants per hour per person were calculated. For harvest activities, time per pound of vegetable harvested, time per unit of vegetable harvested per person, units of vegetable harvested per hour, and units of vegetable harvested per hour per person were calculated. For post-harvest activities, time per unit of vegetable packed, time per unit of vegetable packed per person, units of vegetable packed per hour, and units of vegetable packed per hour per person were calculated. For CSA box packing, time per box packed, time per box packed per person, boxes packed per hour, and boxes packed per hour per person were calculated.

Field Days and Grower Gatherings (3 Field Days proposed):
January 17, 2014 - Grower Gathering to discuss approach (15 attendees)
December 1, 2014 – Grower Gathering to discuss data (15 attendees)
June 14, 2015 – Transplanting Field Day, Crossroads Community Farm (30 attendees)
November 17, 2015 – Packshed in Action, Driftless Farm (30 attendees)
March 8, 2016 – Fairshare Grower Gathering to discuss data (15 attendees)
September 10, 2016 – Cool Tools Field Day, Vermont Valley Farm (30 attendees)

Conference and Workshop presentations (four workshops proposed):
Organic Agriculture Research Symposium, La Crosse, WI – February 25, 2015 (75 attendees)
Organic Vegetable Workshop, Amery, WI – January 22, 2016 (30 attendees)
WI Fresh Fruit and Vegetable Conference, Wisconsin Dells, WI – January 25, 2016 (50 attendees)
CSA Conference, Eau Claire, WI – December 4, 2016 (60 attendees)

B. As stated above, we proposed three field days and four workshops. Both of those benchmarks were met, including additional educational meetings as a farmer-research group, and one-on-one consultation with the farmers involved in the study to present the data, answer questions, and gain insight as to interpretation of results to a broader audience.

Measureable outcomes were determined primarily by number of attendees to the aforementioned programs, as outlined in the proposal. With approximately 30 people attending each field day, we attained participants within the target range. Participation in the workshops was double of our targets, reaching 200 farmers.

Additionally, we had targeted 50 growers to access the project website (veggiecompass.com). Using Google Analytics, we found that over 2000 users had accessed the website in the final year of the project alone, with over 200 of these from Wisconsin.

IV. Beneficiaries

Groups that benefitted from this project include the 200+ organic vegetable producers in this project, as well as the 200+ diversified, direct market vegetable farmers throughout Wisconsin. This more specifically includes the farmers that are part of the Fairshare CSA Coalition, as well as those involved in the Wisconsin Fresh Fruit and Vegetable Association. In 2014, the organic vegetable industry alone netted 17.4 million dollars and organic fruit 3.5 million dollars. This project not only contributes to the maintenance and continued growth of that increasingly significant agricultural sector in Wisconsin, it also contributes to increasing existing farmers bottom lines, without increasing their production base. Calculating a modest 2% increase in gross revenue, this would mean an approximately $400,000 increase for these 200 organic farmers.

Other forms of related outreach include two peer-reviewed journal publications (one accepted, one to be submitted), a Center for Integrated Agricultural Systems Research Brief, grower-focused summaries of research data (to be published as future research briefs), and a series of YouTube tutorials (https://www.youtube.com/results?q=veggie+compass).

V. Lessons Learned

Offer insights into the lessons learned by the project staff while completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project. Provide unexpected outcomes or results that were an effect of implementing this project. If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

The goal of this study was to assess labor efficiency on diversified vegetable farms using a novel approach of time and technique studies, with the aim of evaluating labor productivity in the context of farm size and production, harvest, and packing mechanization. With the approach described in this paper, we documented a tremendous degree of farm-to-farm variation in labor productivity, confirming the value of farm-specific evaluations to estimate cost of production.

The high level of variability in labor productivity across crops and activities reflects the heterogeneity of approaches to production and management on organic diversified vegetable farms, both within and across farm size classification and level of mechanization. For example, with the use of a specific tool (e.g., a barrel washer used in carrot post-harvest activities), techniques for the use of that tool and associated division of labor varied widely. While the

analysis is limited to the five crops included in this study, the results are a starting point to allow farmers to evaluate labor efficiency and production costs on their farms.

Our data also highlight several important aspects of diversified vegetable farm management and costs that could assist farmers in scaling up to meet the product demands of our local and regional food systems. Among the variables examined, mechanization and farm size impacted the productivity and efficiency of most crops and activities. However, these relationships are not absolute across all crops and activities, nor do they entirely explain labor productivity. Yet, they explain what sets some farms apart with respect to efficiency, and indicate crops or activities that can benefit from adoption of machinery or are more suitable for scaling up production. This information could help farmers make more strategic decisions – both with regard to machinery purchases and crop specialization – that could better position them to supply greater volumes of produce to wholesale distributors or food hubs serving local and regional markets, while still remaining price-competitive and profitable.

While availability of labor and worker welfare certainly influence the decision to purchase equipment, considerations such as crew size, farm land base, and worker welfare are also important elements in the assessment of the advantages to each mechanized process. In our study, mechanization resulted in significantly higher labor productivity for all transplanting activities, carrot harvest, and post-harvest activities. Transplanting by hand is very labor-intensive across all crops, and mechanized transplanting has the potential to increase labor productivity up to tenfold. However, crew size remains a critical consideration, as mechanized transplanters require an average of four to five crew members. As such, farms with fewer crew members may not be able to support the use of mechanized equipment, such as a waterwheel or carousel transplanter. Logistical concerns about space and turning radii must also be factored into decisions for mechanization. Activities for which the mechanized process did not show significantly higher labor productivity as compared to the non-mechanized process were usually attributable to a major difference in crew size or inexperience with equipment.

VI. Additional Information

Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

VII. Contact Info

Erika Jones
FairShare CSA Coalition
303 S. Paterson Street #1B
Madison, WI 53703
608-226-0300
Erika@csacoalition.org

10) Cranberry flea beetle biology and management (FY13-010)

Report Date: August 15, 2015

I. Project Summary

Wisconsin produces more cranberries than all other States combined, but in recent years our growers have had to endure a pest problem that other cranberry-growing regions have largely avoided: feeding damage by the cranberry (red-headed) flea beetle, *Systena frontalis*. The remarkably rapid rise of the cranberry flea beetle in central Wisconsin (Wood, Monroe, Jackson, Juneau, and Portage counties) has been sustained over five growing seasons, suggesting the rise is not just an itinerant problem. This single pest species has caused a spike in insecticide spraying on many Wisconsin marshes, which has increased insecticide residue levels in fruit and put Wisconsin growers at a competitive disadvantage. While the residue levels are within legal limits for the U.S. market, they exceed the levels designated for European and Asian markets. As a result, Wisconsin growers are in need of a way to control flea beetle populations while reducing residue levels in their crop.

Until the initiation of the current research project, it was not known exactly how or where the flea beetle overwintered in the cranberry growing regions of Wisconsin. Flea beetle overwintering biology is important because growers need to know if a single early-season soil-drench can replace the typical 2-3 late-season foliar insecticide applications. Before we initiate large-scale soil-drench trials, we must determine whether flea beetles overwinter predominantly within the cranberry bed or the dikes. Thus, we investigated where flea beetle larvae hatch/feed in the spring, and then how best to control them with a single early-season insecticide application.

Our specific objectives were to 1) characterize flea beetle overwintering biology and mid-spring emergence patterns, 2) collaborate with commercial growers to test the efficacy of soil-drenches timed for the larval emergence, and 3) disseminate our findings as widely as possible within the cranberry industry. The deliverable information and technology from this project included 1) knowledge of flea beetle biology and 2) a wiser, more reliable approach to flea beetle management. This management approach represents a significant departure from standard practices--targeting a pest within subterranean feeding galleries, and shifting the application timing to a point early enough in the season to eliminate issues with insecticide residues in fruit. The work had potential to reduce pest control costs, reduce environmental threats, and ultimately, expand the international market for Wisconsin cranberries.

B. This project did not build upon past SCBGP-funded work.

II. Project Approach

Studies of flea beetle overwintering biology: In the 2013 growing season, specimens of the cranberry (red-headed) flea beetle (Fig. 1), as well as plant tissue samples, were processed for flea beetle biology experiments. Studies of the overwintering biology were located at two commercial cranberry marshes in Wisconsin. Emergence cages were placed either on the dike or in the cranberry bed, following cranberry bloom. The cages were 15 ft. (4.6 m) in length by 3 ft. (0.9 m) in width by ft. (0.5 m) in height. Cages were supported by wire hoops and enclosed with a spun polyester fabric that has 90% light transmission. The fabric was secured at the soil surface using bio-degradable starch staples. Adult flea beetles were collected weekly from the cages using a vacuum-based insect collection device (D-vac). Collected beetles were transferred to a plastic bag and stored over ice until reaching the laboratory and subsequent stored at -20°C.

Fig. 1. Cranberry (red-headed) flea beetle, *Systena frontalis* (adult).

Soil-soak trial #1: 3 field sites were selected according to variety, region, and history of flea beetle infestation. Insecticides were applied to the canopy and drenched into the soil with irrigation one week prior to bloom and one week following bloom to small plots within the cranberry bed. Each of the following treatments was applied to four plots before bloom: Altacor®®, Delegate®, Belay®, and NematacC. After bloom: Belay® alone. Control plots that received no insecticidal soil drench were included at each marsh. Emergence cages were installed over treated and control plots to contain any adults. Feeding damage and adult populations were monitored each week. When data from our insecticide trials were analyzed, the post-bloom Belay® treatment was the clear stand-out, providing significant reductions of flea beetle populations.

Extension/Outreach: In the winter of 2013-2014 (at the Winter Cranberry School meeting, Wisconsin Rapids, WI), we used a remote "clicker" system to survey a crowd of 90-100 self-selected audience members from a pool of 400-500 cranberry growers. Our questions assayed grower understanding of flea beetle biology, as well as their typical management practice(s). This information will serve as a baseline to assess changes in understanding and/or management arising from our work.

Feeding depth of larval flea beetles: In spring, 2014, flea beetle specimens and plant tissue samples were submitted for isotopic analysis. Our samples were analyzed for 15N and 13C signatures at the University of California-Davis isotopic analysis laboratory. The isotopic "fingerprints" of insects such as flea beetles draw a tight link between a consumer and their diet, which means we can discern where the flea beetle larvae have fed, regardless of where we find the adults mid-summer. Our isotopic analyses involved beetle elytra (parts of the exoskeleton that mirror larval feeding only) and cranberry roots at 3 different depths. We also surveyed isotopic signatures within the roots of broad-leaf weeds on the raised borders (dikes) of the cranberry beds.

Soil-soak trial #2: In early summer 2014, we conducted field trials involving the insecticide Altacor® (chlorantraniliprole), which is a new and very effective insecticide for cranberry growers in Wisconsin. The insecticide Belay® was not tested due to substantial concerns over the use of neo-nicotinoids on a fruit crop (Ocean Spray Cranberries, Inc., clearly indicated that no fruit treated with Belay® would be allowed into its processing centers). At five large commercial marshes in Wisconsin, insecticide and control treatments were applied to beds (3-4 acres each) immediately post-bloom. Two replicates (beds) of the treatment and controls were established at each marsh, and each bed was pre-irrigated to thoroughly saturate the canopy and duff layers, preventing adsorption of the insecticide active ingredient onto leaf surfaces. After pollinators had been removed from the marshes, the insecticide, Altacor®, was applied at a rate of 4.5 oz/acre in 50 gallons H2O/acre along with 2.5% FS Aqualite (Growmark; Bloomington, IL) by volume, a nonionic surfactant. The nonionic surfactant was used to help move the insecticide into and through the soil profile. Immediately after Altacor® application, treated beds were irrigated for an additional four hours. Control beds received only the irrigation set, and thereafter were treated as per the specific grower's management regime. Flea beetle counts commenced in July and ended in early September. Adult flea beetles were sampled with a sweep net on two dates post treatment. Ten sets of 20 sweeps were conducted in each study bed for a total of 200 sweeps bed. In terms of adult flea beetles, there were no differences between the Altacor® and control treatments.

Soil percolation of insecticide: Soil samples were taken within 24 hours of the Altacor® application in order to measure Altacor® presence throughout the soil horizon and determine the efficacy of the application methods. The 24 hour sample was not possible at two of the marshes due to restricted entry intervals of other pesticides that were applied on the same day. Soil samples were taken to 10" with a probe 1" in diameter. Ten samples were taken per bed. Altacor® was successfully delivered to the soil profiles where flea beetle larvae feed.

Impacts on grower practices: In the winter of 2014-2015 (at the Winter Cranberry School meeting, Wisconsin Rapids, WI), we again used a remote "clicker" system to survey a crowd of 90-100 self-selected audience members from a pool of 400-500 cranberry growers. This information allowed us to assay changes to grower knowledge of flea beetle biology and control tactics.

III. Goals and Outcomes Achieved

Performance goals

1) Illuminate critical elements of flea beetle biology that will improve control efforts;

2) Test efficacy of soil-soak control tactics;

3) Improve grower understanding of flea beetle biology and control tactics, thereby improving flea beetle pest management in Wisconsin.

Major activities/outcomes re: performance goals

1) FLEA BEETLE BIOLOGY: The subterranean feeding habits of the cranberry flea beetle (Fig. 1) larvae were successfully documented over the course of 2012-2014. We have shown that the larvae feed at relatively shallow depths, making them amenable to soil-soak treatments. Using the isotopic signatures (15N and 13C) of flea beetles, as well as the cranberry roots on which

they feed, we demonstrated that the larvae primarily feed on roots within the top 1-4 cm of soil, while relatively few feed 4-8 cm deep. These findings reveal the depth to which a soil-soak insecticide must percolate (i.e., only the top 8 cm of soil need be treated, avoiding the water table of the marsh).

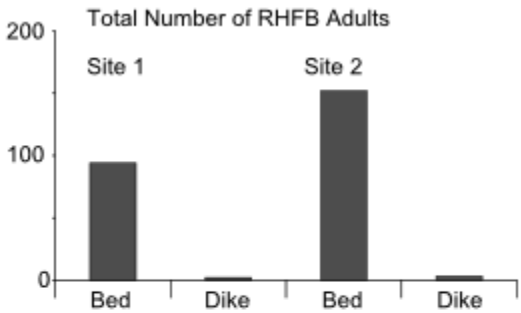


Figure 2: Total number of RHFB Adults recovered from emergence cages. Eight cages were placed in each location, bed or dike, at both sites. Adults were collected each week from July until August.

Our work also shows that the cranberry/red-headed flea beetle (RHFB) develops almost exclusively in cranberry beds, not the dikes that surround the beds. Very few adults emerged within our dike cages, while many emerged within the cages set up in the beds (Fig. 2). This finding allowed us to "put to rest" questions relating to flea beetle immigration from dikes or other off-site locations. This also suggests that soil treatments should be applied to beds only. The adult beetle emergence was prolonged, lasting approximately 1 month (Fig. 3), highlighting the need to treat the entire flea beetle generation when they are feeding underground as larvae, rather than waiting for adults to slowly emerge from the soil. Altogether, these findings established the basis for our trials of soil-applied insecticides.

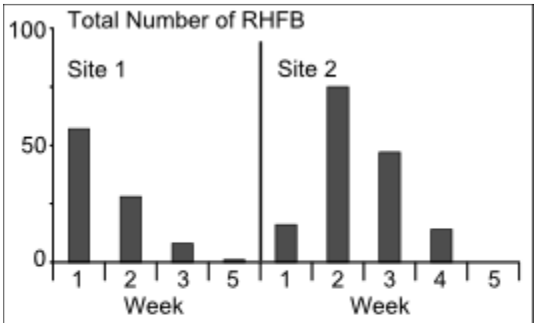
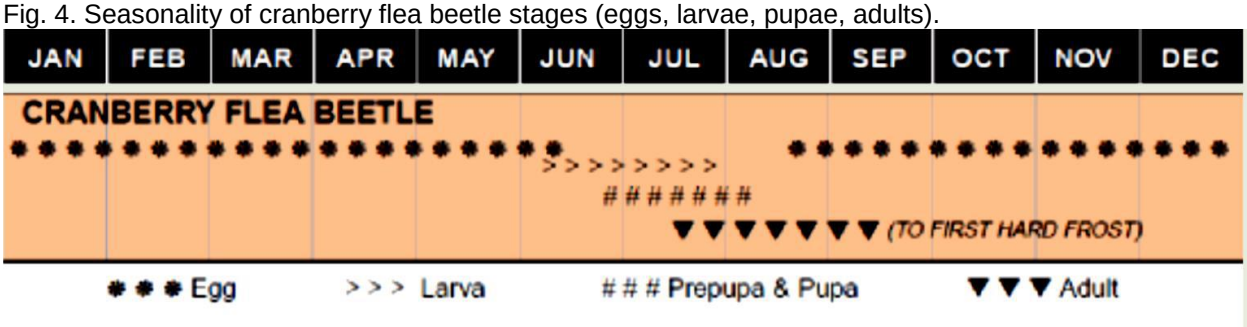


Figure 3: Weekly total of adult RHFB caught in emergence cages. This is another way to represent the data in Figure 2.

2) SOIL-SOAK EFFICACY TRIALS: Soil-soak treatments were conducted over the course of two summers. Treatments were applied either pre-bloom (early June) or post-bloom (late July), timed for the larval stage of the flea beetle (Fig. 4). All of the pre-bloom treatments (Belay®, Altacor®,

Fig. 4. Seasonality of cranberry flea beetle stages (eggs, larvae, pupae, adults).



Delegate, NematacC,untreated control) were no better than the control, while the single post-bloom application of Belay® was significantly better than the control (Figs. 5). In terms of crop protection potential, Belay® applied post-bloom was the superior insecticide/timing for a soil-application (Fig. 6). Following this trial, it remained to be discerned whether Altacor® or Delegate might also work well if applied post-bloom. So, in 2014, we chose to test Altacor® because of its proven record of pest control when applied to foliage. Our 2014 replicated trials (Altacor® vs. controls) were examined across three marshes. Based on this work, Altacor® did not appear to be an effective material for flea beetle control (Fig. 7). To verify that residues of

Altacor® had actually penetrated the soil profile, reaching the depths needed to treat flea beetle larvae, we took soil cores during the experiment. Based on the residue data (Fig. 8), the active ingredient of Altacor® clearly percolated deep enough to reach most, if not all, the flea beetle larvae. Despite having delivered the insecticide to the larvae, mortality was insignificant. The failure of Altacor® to control flea beetle populations emphasizes the important role that Belay® represents within the cranberry IPM programs of Wisconsin.

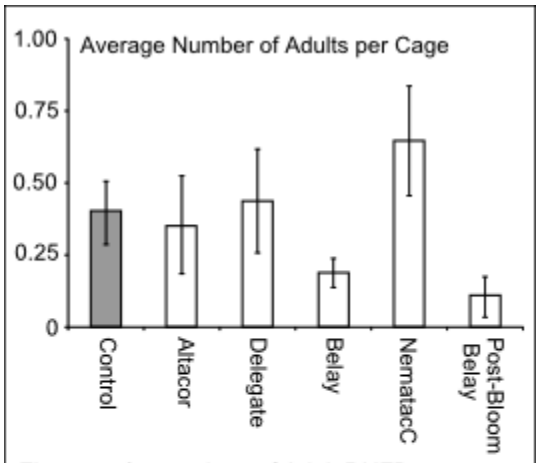


Figure 5: Comparison of Adult RHFB counts between soil drench treatments. Each plot was caged and sampled each week. A short ten second sampling with an insect vacuum was performed three times per cage. Very low numbers of adult RHFB were found with this method and were not statistically different. However, this trend is similar and significant for upright damage.

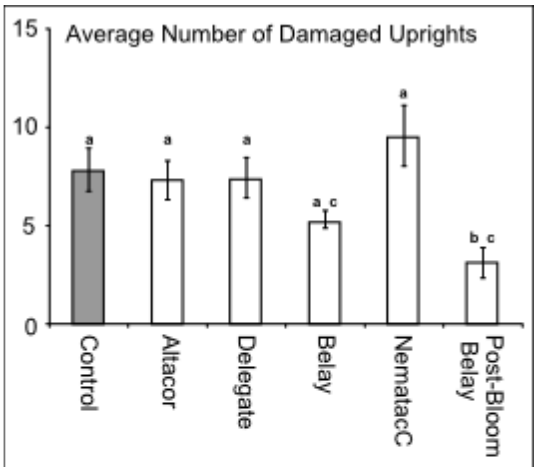


Figure 6: Comparison of upright damage levels between soil drench treatmens. Altacor, Delegate, Belay, and NematacC were applied before bloom. After bloom, Belay was applied. Each treatment was replicated with four small plots at three commercial cranberry marshes. Treatments that share a letter, e. g. "a", are not statistically different. The post-bloom belay application is the only treatment different from the control.

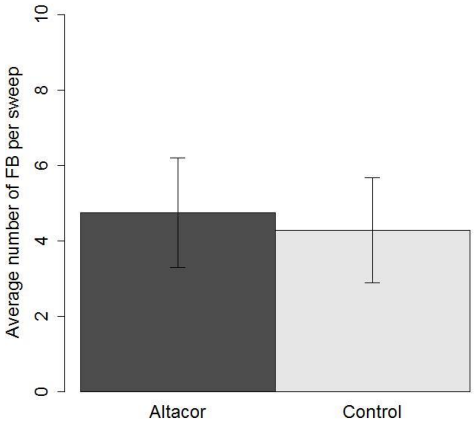


Fig. 7. Number of adult flea beetles found in Altacor® residues at two soil depths within treated beds treated with Altacor® soil soak, vs. untreated control.

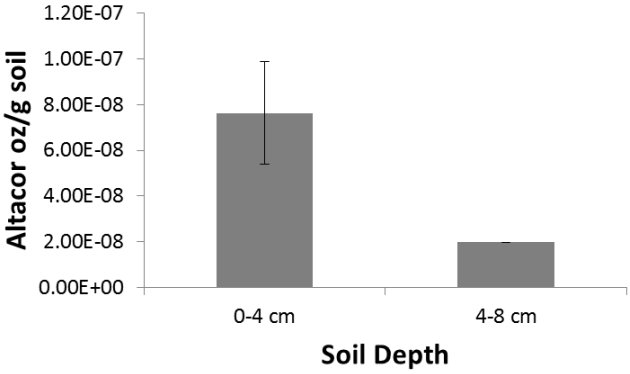


Fig. 8. beds.

3) IMPACTS ON GROWER KNOWLEDGE AND PRACTICES: In the winter of 2013-2014, we measured grower knowledge of flea beetle biology and pest management practices. This served as the baseline to assess changes in grower knowledge and behavior, which was measured again one year later during the winter of 2014-2015. From the initial assessment (86 respondents), we found that insect pests commanded a disproportionate amount of pest management effort (47% of pesticide sprays were insecticides, versus those of fungicides and herbicides), and 96% of all growers applied 2 or more insecticides per year. On average, 40% of these were directed *strictly* for flea beetle. 88% of Wisconsin cranberry growers believe that spraying for flea beetles is worth the expense. 15% of growers believed that flea beetles overwinter in the dikes, while 13% believed they overwinter exclusively in the beds (some growers were unsure, and 63% believed that flea beetles may overwinter in both the beds and dikes). Of the flea beetle sprays, 72% were applied only to beds, while 28% were directed at beds and dikes. This means that much insecticide was applied to (and thus wasted on) the dikes.

One year later (winter, 2014-2015), insects were again the top pest management concern for growers (89 respondents), with 94% of growers applying 2 or more insecticide sprays during the previous growing season. Most growers now understood that flea beetles overwintered largely in the beds, not the dikes (80% of respondents indicated flea beetles overwinter in beds, a major increase from the 13% of the previous year). 17.3% of growers still thought that flea beetles overwintered in the dikes, and 2.7% believed they overwintered off-site (Fig. 9). This represented a major improvement in grower understanding of flea beetle biology. 36% of all sprays were *strictly* for flea beetles, and of these, 97% were applied to the beds (compared with 72% in the previous year), suggesting that grower pest management practices had changed in response to their new understanding of pest biology.

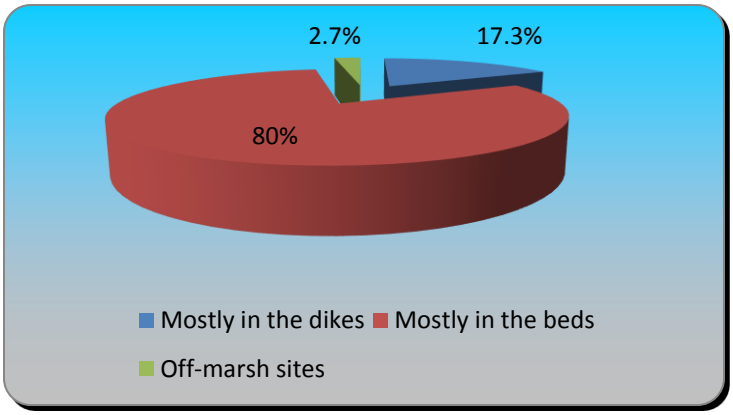


Fig. 9. Grower knowledge of flea beetle overwintering sites.

Ongoing, long-term activities:

NEW BIOLOGICAL CONTROL PROGRAM: Insecticides are generally relied upon to "knock back" a pest population, but each day, biological controls (natural enemies) feed on pests, consistently suppressing their populations. One particular group of insect-eating organisms, nematodes, are the most numerous natural enemies in native cranberry bogs. Given that cranberries and their pests are native to North America, we have initiated a program to discover and isolate native nematodes as biological control agents.

In the summer of 2014, we successfully recruited a PhD student to begin statewide surveys of entomophagous (insect-eating) nematodes in the native marshlands of Wisconsin. To-date, three different entomophagous nematode species have been isolated, all of which appear to be new to science, and all of which are pathogenic to the sparganothis fruitworm, a major pest of Wisconsin cranberries. These three nematodes represent promising candidates for a future soil-soak deployment system.

B. Our work was successful in 1) illuminating key elements of flea beetle biology, 2) finding an effective, safe, early-season treatment for flea beetles, and 3) presenting our findings to the Wisconsin cranberry industry. Following our education efforts, we documented a significant increase in grower understanding of flea beetle biology, which led to improved pest management. Altogether, this represented a genuine, positive impact on grower practices.

Despite meeting our goals and continuing to provide this information to growers, an unanticipated problem did emerge relating to a particular decision by the largest cranberry processor/retailer in the world, Ocean Spray Cranberries, Inc. This company effectively banned the neonicotinoid, Belay®, from use on any marsh because of the negative associations with honey bee declines. This was unfortunate, particularly given that our application timing was *post-bloom*, and that no insecticide residues were detectible in the fruit harvested from our research plots (residue data were determined by Ocean Spray and Valent, the company that manufactures Belay®). Thus, despite the fact that we had successfully side-stepped the bee issue by applying this insecticide after the bloom period, and had evidence that there were no Belay® residues in the berries, this insecticide was still deemed too risky by Ocean Spray, Inc. As such, this compound was no longer available for flea beetle control, and we were forced to investigate another insecticide, Altacor®. This insecticide clearly did not perform as well as Belay®.

While our Wisconsin growers were able to improve their IPM practices (97% now exclusively treat beds, not dikes), their sprays were all *foliar* applications, not soil-soaks, and were often applied late-season (Aug, Sept), increasing the likelihood that excessive insecticide residues were present in the harvested crop. Additionally, the foliar application approach generally required multiple applications. It is critical, therefore, to continue the search for a viable, effective early-season soil-soak.

IV. Beneficiaries

Wisconsin cranberry growers and their attendant industries (e.g., material suppliers, pest management consultant services) are the major beneficiaries of this project. There are over 250 growers in the State, employing thousands of workers. By improving grower understanding of flea beetle biology and optimal IPM approaches, pest management in Wisconsin's cranberry systems has been made more efficient.

V. Lessons Learned

Our field work revealed that it is extraordinarily difficult to locate flea beetle larvae using soil cores. After taking ~400 cores and devoting over 300 person-hours to screening the soil, only a single larva was found. This is was an important learning experience for the lab, and highlighted the importance of creating lab cultures of this beetle. To assess flea beetle populations in the field, it is much more efficient to sample for adults via a sweep-net or D-vac.

VI. Additional Information

Presentations and publications were made at the winter cranberry meetings (2013, 2014, and 2015) and spring workshops (2013, 2014). Proceedings of the Winter Cranberry School can be found at the Wisconsin State Cranberry Growers Association website.

VII. Contact Info

Shawn Steffan
College of Agriculture and Life Sciences
University Of Wisconsin - Madison
545 Russell Laboratories
1630 Linden Dr
Madison, WI 53706
(608) 890-1281
steffan@entomology.wisc.edu

11) Restaurant rewards: growing the wholesale market for fresh fruits and vegetables (FY13-011)

Report Date: August 29, 2016

I. Project Summary

A. Since REAP's Buy Fresh Buy Local (BFBL) program began, we have been collecting purchasing data from partner restaurants. Restaurants are required to report their annual local food purchases by category -- dairy, meat, vegetables, fruits, and prepared food. Their reporting includes vendor names and amount purchased. Data shows that direct local purchases by Buy Fresh Buy Local partners grew from an estimated $760K in 2007 to an estimated $3M in 2012. Analyzing the reported data, total local foods purchases have grown an average of 25% per year, while the fruit and vegetable categories have only grown an average of 3% per year.

This project addresses this imbalance of local foods purchasing growth by creating a Restaurant Rewards (RR) program intended to bring Wisconsin specialty crops to the "center of the plate" at local restaurants. This project rewards food-service establishments based on 1) how well they showcase Wisconsin specialty crops through promotional advertising and in-house signage, 2) the number of specialty crop farmers they purchase from, and 3) the percentage of Wisconsin-grown produce purchased out of the total amount of produce purchased.

In the past seven years, there has been significant growth in the purchasing of local foods by the Wisconsin restaurant industry. However, our data shows that while purchases of dairy, meats, and prepared foods are growing, the percentage share of local produce has not kept up with overall growth. This is timely as consumers become more health conscious and local sourcing remains one of the top WRA trends. Restaurants will need to continue to respond to these trends and consumer demands but increasing transparency and promoting local purchasing as well as offering larger amounts of fruits and vegetables.

This project incentivizes becoming more aware of the abundance of Wisconsin produce available and forms new connections with specialty crop farmers. Wisconsin specialty crop farmers see an increase in sales to restaurants, and consumers learn about Wisconsin specialty crops through the promotional efforts of restaurants. In addition to implementing the rewards program, REAP Food Group created a beginner purchasing toolkit, specific to Wisconsin, to help restaurants navigate through the process of purchasing locally-grown fruits and vegetables. This toolkit serves as a marketing guide, giving chefs and restaurant owners' examples and ideas on how to better advertise and market their use of locally-sourced produce.

B. N/A.

II. Project Approach

November 2013 – January 2014: Create program guidelines, advertising templates, reimbursement rubric, restaurant application, and reimbursement form.

During this time frame, we focused on strategic development of the program by defining the program parameters, developing program language, designing outreach materials, and setting the reimbursement rubric guidelines.

While designing the reimbursement rubric for the BFBL partner restaurants, we wanted to accommodate restaurants of different scales. To do this, we created a point system in which partner restaurants were evaluated in three categories: 1) new promotional activities 2) 2014 purchases of specialty crops in dollar amount and 3) specialty crops as a total % of total food purchases. Each category had three potential point levels.

Smaller scale restaurants could score pretty well if they purchased a high percentage of specialty crops, whereas a larger restaurant would also score well if they purchased a higher dollar amount, even if it was a lower percentage of specialty crops out of their total food purchases.

One adjustment we made was to issue and process the reward payments in January rather than letting them flow in throughout the year as originally planned. Because our partner renewals run January to January, and we collect all their purchasing data at this time it was easier to verify their specialty crop purchasing claims at that time.

January – March 2014: Send out program information and applications to BFBL partner restaurants.

Based on the materials we designed in the early winter, we first sent out a paper mailing including an intro letter, the grading rubric, and a form to send back. We also included an analysis on how we think they would currently score if their purchases stayed at the same level, to give them some motivation. We emailed each of the restaurants, spread the word on social media, and spoke with restaurateurs over the phone and in-person. Twenty of our restaurant partners said yes and another handful of partners gave us positive verbal feedback saying they weren't sure they could meet the requirements but were definitely interested in moving towards that goal.

March – April 2014: Schedule one-on-one meetings with restaurants to review grading rubric. Establish marketing goals and sourcing goals.

The program director worked one-on-one with 18 different restaurant partners during this period to source various specialty crops and to help them establish their specialty crop sourcing and marketing goals for the season.

March 2014 and onward: Help chefs identify specialty crop farmers and facilitate conversations.

Farmers contact us if they are interested in selling to restaurant buyers and then we pass the information on to the buyers. The program director actively does outreach to farmers so they know this resource is available. Farmers often contact us specifically if they have a bumper crop of something and want to sell them at a discount. These one-time purchases of discounted products quite frequently become a door opener for the farmer to develop regular selling relationships for other products. One unexpected development is the amount of aquaponic and fresh herb growers in the state that have been contacting us,

primarily from the Milwaukee area and the southwestern part of the state. We have had at least 6 contact us since the beginning of the project.

Additionally, chefs will contact us looking for a specific product or several fruits/vegetables and we are then able to refer them to several different farmers. For example, Ian's Pizza contacted us about getting local tomatoes for their August/September special, and we connected Ian with several different tomato farmers, and were able to go out and take photographs to document and share on social media.

In 2014, a Facebook group was created for chefs to talk with each other about sourcing. REAP participates in this by posting information about farmers that have product available. This continues to be a great tool to communicate time sensitive information and reach buyers in a new capacity to increase participation.

In 2014, REAP coordinated a series of buyer-farmer networking sessions which were attended by 50 unique people total, 15 buyers and 35 farmers. These were not exclusive to specialty crop focus, however, many of the farmers who attended do sell WI grown fruits and vegetables, and we have seen several relationships result from this activity.. For example, an aronia berry farmer came to a networking meeting who has fresh and frozen product, and two of our bakeries are now using his products. In December of 2014, we hosted the last producer-buyer happy hour that was attended by one buyer and four producers. This low attendance and additional feedback from chefs indicated that the producer-buyer happy hours were not a priority or the most useful introduction tool. Since then, we have shifted this energy to more focused individual producer and buyer outreach.

The Coopers Tavern held an heirloom tomato-themed dinner in August, 2014 and 2015 as part of their effort to increase exposure to local produce. The chef met a farmer at one of our networking events and purchased tomatoes from him. This is a good example of building a relationship that benefits the farmer while increasing public awareness of specialty crops. Additionally, Harvest Restaurant hosted a Cider Dinner in October of 2014 and October 2016 featuring local apples and cider.

<u>Summer 2014 and onward: Reimbursement requests – verify marketing purchases, process and issue reward payments</u>

We continued to work closely with farmers and chefs to keep an eye on purchases and opportunities to integrate more local produce in our partners menus. We continued to monitor restaurant media and marketing outreach efforts to publicize their use of WI grown specialty crops, specifically through social media efforts like facebook and instagram. Some restaurants promoted local producers through an interactive trivia post about the producer, others highlighted their seasonal specials tagging the local producers. Some proudly shared their Restaurant Rewards award.

<u>October – December 2014: Begin research for how-to purchasing toolkit.</u>
During this time, Sarah Larson was hired as the new Farm to Business Program Director, replacing Theresa Feiner in that position. Sarah was oriented and took over the responsibilities of implementing the Restaurant Rewards Program.

Sarah conducted a literature review and a series of in-person interviews to inform the content for production of a how-to-purchasing toolkit to be titled, "Buying Local Produce – A Guide for Restaurants" Chefs were polled for promotional and purchasing stories, toolkit content was outlined, and contributing writers and reviewers were recruited.

December 2014 – February 2015: Collect 2014 Purchasing Data

During the winter, the Program Director drafted the content for the how-to or "Buying Local Produce – A Guide for Restaurants" guide. A release date of early March was targeted to align with the annual MidWest Foodservice Expo (the flagship event put on by project support partner the Wisconsin Restaurant Association (WRA)). The guide content was sent to a panel of reviewers, and then underwent three rounds of design and editing, culminating in the production of a 14 page, 8.5" x 5.5" guide. Our partnership with the Wisconsin Restaurant Association was instrumental in design and dissemination of this toolkit. Comparable projects should seek to leverage association and extension partnerships as much as possible.

During this time, restaurants participating in the rewards program were polled for their purchasing and promotional data to be analyzed for the first round of rewards.

March – April 2015: Work with the Wisconsin Restaurant Association to reach out to restaurants statewide through mailings and email.

In early March, 1,000 copies of the toolkit were printed, exceeding the originally proposed plan to print only 200 copies. Printing on this timeline aligned with the WRA Midwest Foodservice Expo that took place in Milwaukee from March 9th through 11th. REAP's Buy Fresh Buy Local Program tabled at this event and distributed over 700 copies of the toolkit. We were also invited to lead a series of small discussions on buying local as part of a new expo feature #questions#answers. Sarah led four of these small group sessions reaching over 30 interested local purchasers.

During this period she continued to collect purchasing data and promotional examples as data for awarding the first round of Restaurant Rewards. Data reflected that restaurant partners increased purchases of Specialty Crops through several innovative ways, such as incorporating local produce in beverage specials, integrating items in seasonal specials, and hosting specialty events highlighting local produce. Partner's created new promotional strategies for local produce through staff engagement (field trips), vimeo videos highlighting in season preservation, new menu and signage, and using social media to promote farmers' market relationships and local/seasonal specials.

Cumulative year end data for all partners showed that $644,250 was spent on local Special Crops. This data shows a 9% increase in Wisconsin Specialty Crop purchases from our 2012 benchmark of $540,000. While this growth is a good start, there is much progress to be made to successfully reach our goal of $873,750 by the end of the second year..

April 2015 and onward: Continue to work with chefs to increase specialty crop purchases and to promote partners in innovative ways.

In addition to distributing copies of the toolkit at the WRA Midwest Foodservice Expo, the WRA shared our toolkit with their entire statewide network digitally. REAP created a prospect list of 25 locally-owned ethnic restaurants and dropped off invitations to participate in the second round of the Restaurant Rewards program. We found that restaurants were interested in person but response and follow through was low through this outreach. It is clear that more intensive outreach is needed to bring in new-to-local purchasing partners. REAP is looking at additional ways to reduce these barriers to entry through peer-to-peer mentoring and more direct service efforts.

Throughout the entire period of this grant, farmers and chefs have reached out to the program director with specific selling or purchasing needs. Sarah actively serves as a broker and matchmaker to facilitate sales to meet these requests. Farmers often contact us specifically if they have unexpected excess product they need to sell quickly. More often than not, we have been able to match those products with restaurant buyers. These one-time purchases of (sometimes discounted) products have frequently become a door opener for the farmer to develop repeat sales and establish a selling relationship for other products. Sarah has contacted over 30 Specialty Crop farmers to let them know she can act as a resource in this way.

Summer 2015 and onward: Reimbursement requests – verify marketing purchases, process and issue reward payments

Through the late spring and early summer, Sarah finalized data analysis from the participating partners. In June awards were given to ten Buy Fresh Buy Local Partners, ranging from $375 to $500 based on a rubric of success in Specialty Crop purchasing growth and new promotional efforts. In total, $4000 was awarded in this first round.

Chefs were encouraged to capitalize on the produce growing season, and develop new ways to market products. We worked with a freelance graphic designer to design a template table tent, flat table top plexi insert, facebook ad, Edible Madison ad, and a sourcing map to motivate chefs and restaurants to promote specialty crop producers in new ways.

We continued to track restaurant media and marketing outreach efforts to publicize their use of WI grown specialty crops.

Fall 2015: Implement program outside of Buy Fresh Buy Local Partners

We worked with a graphic designer and the Great Lakes Farm to School region to promote a new promotional opportunity for our BFBL partners. This innovative partnership involved cross promoting Buy Fresh Buy Local and Farm to School through October Farm to School Month and the Great Lakes Great Apple Crunch. Restaurants were asked to source local apples and promote these partnerships on promotional templates/materials designed by REAP. They were also asked to engage staff through an actual apple crunch – where all "crunch" into a local apple at noon on October 22nd and share the photo on social media. Three restaurants participated.

We requested an extension for the end date of this grant, so that we could fully capture the summer's produce season with a second round of rewards. In this second round we continued to circulate information and solicit interest from restaurants outside of the Buy Fresh Buy Local program. (We circulated information to a prospect list of 25 restaurants from around the state.)

Winter 2015 - Spring 2016 - Collect and Analyze Year Two Data
In January of 2016 we presented on the Restaurant Rewards Program at the Wisconsin Local Food Summit.

During this period we collected data from our 46 restaurant partners and followed up with non BFBL partner leads. This included 10 restaurants from the MidWest Foodservice Expo as well as follow up to another 15 restaurants from the WI Local Food Summit and previous promotion.

Late Spring 2016
In a second round of awards, REAP issued 19 Restaurant Reward Awards to 18 BFBL partner restaurants and 1 non BFBL partner restaurant totaling $6,750 in awards. REAP hand delivered framed Restaurant Rewards certificates to all 19 BFBL partners. Each delivery was photographed and shared on social media. Our Restaurant Rewards Album was the topped viewed post on our BFBL facebook page reaching over 4800 people and receiving 798 post clicks and 344 reactions, comments, and shares. We recommend that that a rewards program be paired with a promotional aspect like a certificate.

Summer 2016
As a final activity for this project, REAP Food Group worked with UW Extension to plan a co-hosted training event called Selling Local Produce to Wholesale Markets.. This event will expand our Buying Local Produce - A Guide For Restaurants to broader audience including institutions like hospitals, schools, and retailers. It will also focus on bringing producers and buyers into the room to discuss how to best maintain and sustain local produce purchasing relationships. We anticipate reaching over 40 producers and buyers at this event.

III. Goals and Outcomes Achieved

A. Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project. If outcome measures were long term, summarize the progress that has been made towards achievement.

Activities Completed

Program promotion and outreach - internal: Twenty of our BFBL restaurant partners indicated interest in participating in our RR program at the start of year one. Another handful of partners gave us positive verbal feedback saying they weren't sure they could meet the requirements but were definitely interested in moving towards that goal.

Toolkit creation: In early March 2015, 1,000 copies of the toolkit were printed, exceeding the originally proposed plan to print only 200 copies. REAP's Buy Fresh Buy Local Program tabled at the Midwest Foodservice Expo and distributed over 700 copies of the toolkit.

Program promotion and outreach - external: In March of 2015 we promoted the Restaurant Rewards program at the Midwest Foodservice Expo through hosting a booth and leading a series of small discussions on buying local as part of a new expo feature #questions#answers. Sarah led four of these small group sessions reaching over 30 interested local purchasers.

Sarah presented on the Restaurant Rewards Program at the 2016 Wisconsin Local Food Summit to a group of 20+ attendees.

In March of 2016, Sarah presented on "Buying Local 101 for Restaurants" at the MidWest FoodService Expo's inaugural Buy Local conference. She also hosted another series of small group discussions. An additional 100 toolkits were disseminated at this event.

Year One Program Participation: In June 2015 awards were given to ten Buy Fresh Buy Local Partners, ranging from $375 to $500 based on a rubric of success in Specialty Crop purchasing growth and new promotional efforts. In total, $4000 was awarded in this first round.

Year Two Program Participation: Issued 19 Restaurant Reward Awards to 18 BFBL partner restaurants and 1 non BFBL partner restaurant totaling $6,750 in awards. REAP hand delivered Restaurant Rewards certificates to all 19 BFBL partners. Each delivery was photographed and shared on social media. Our Restaurant Rewards Album was the topped viewed post on our BFBL facebook page reaching over 4800 people and receiving 798 post clicks as well as 344 reactions, comments, and shares.

Conference Participation/Trainings Held: Attended the MidWest Foodservice Expo in 2015 hosting a buy local both and four small group discussions. Presented at the Buy Local conference (a subconference of the MidWest Foodservice Expo) in 2016, Presented on the Restaurant Rewards program the Wisconsin Local Food Summit in 2016. Will host a conference on Selling Local Produce to Wholesale Markets in September of 2016 and will present on Buying Local 101 at the September Southern Wisconsin Association of Foodservice Professionals meeting.

Promotional Data Collection: The Restaurant Rewards data collection process allowed us to create a list of successful and innovative specialty crop promotions. Examples range from promoting a farmers' market cocktail to becoming a CSA drop site and creating a weekly meal highlight the ingredients in the CSA. Not only did these examples inform the development of our toolkit, they are integrated into our BFBL program and general buyer conversations.

B. Goal 1: To increase sales of Wisconsin specialty crops to an estimated 50 participating restaurants
Performance measure: Restaurant purchasing data
Benchmark: $540,000 reported annual purchases of Wisconsin specialty crops in 2012
Target: $873,750 reported annual purchases of Wisconsin specialty crops by the end of year 2.

At the end of year one (2014), cumulative data for all partners showed that $644,250 was spent on local Special Crops. This data shows a 19% increase in Wisconsin Specialty Crop purchases from our 2012 benchmark of $540,000. While this growth is a good start, there is much progress to be made to successfully reach our goal of $873,750 by the end of the second year.

At the end of year two (2015), cumulative data for all partners showed that $723,159 was spent on local specialty crops such as vegetables and fruit. This data shows a 34% increase from our 2012 benchmark of $540,000 and a 12% increase over our 2014 results of $644,250.

During the total period of our grant we saw specialty crop purchases increase 34% or over $180,000. Though these results are $150,590.23 or 17% short of our year end goal of $873.750 we believe we will continue to see increases in specialty crop purchasing.

Goal 2: Disseminate best practices results to restaurants across Wisconsin
Performance measure: # of toolkits distributed, # of conferences/trainings held
Benchmark: 0
Target: 200 printed toolkits, 2 conference/trainings held

In early March 2015, 1,000 copies of our 'Buying Local Produce - A Guide for Restaurants' toolkit were printed, exceeding the originally proposed plan to print only 200 copies. REAP's Buy Fresh Buy Local Program tabled at the Midwest Foodservice Expo and distributed over 700 copies of the toolkit. The Wisconsin Restaurant Association disseminate the toolkit to their restaurant group, UW Extension contacted us to link the guide on their resources page, and South Dakota State University Extension asked if they could model a local guide after our resource.

Sarah attended 3 conferences to promote the toolkit including the MidWest Foodservice Expo (in 2015 and 2016) and the Wisconsin Local Food Summit (2016). She will also be attending two additional conferences in September 2016 as a result of this project but focused on the HealthCare/Food Service Industry: The Southern WI Association for Healthcare Foodservice (AHF) Meeting (September 29th) and The Wisconsin Healthy Hospitals and Clinic Forum (September 30th).

IV. Beneficiaries

Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments. Include quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

- **Restaurants**

Through this program we highlighted purchasing and promotion of Specialty Crops to over 46 restaurant partners. We were also reached out to 25 ethnic restaurants, joined the Latino Chamber of Commerce, and connected with over 30+ restaurants at the MidWest Foodservice Expo.

- **Institutions**

Through this work we were able to extend our Buying Local Produce for Restaurants toolkit to the Institutional market creating a series of fact sheets and Wisconsin-specific resources. This has helped facilitate relationships with institutions like UW Health and producers like Peacefully Organic Produce leading to a commitment to purchase produce each week while in season.

- **Farmers/Producers**

We engaged over 60 specialty crop growers requesting product availability information and resources**.** Through this data and outreach we are able to promote local seasonal produce to our partners and help introduce farmers to potential buyers.

- **Wisconsin Restaurant Association (WRA)**

We were able to promote Buying Local produce at the 2015 MidWest Foodservice Expo and were part of the inaugural 2016 Buy Local subconference at the MidWest Foodservice Expo. The WRA also provided feedback on our toolkit design and disseminated the resource to their restaurant members.

- **UW Extension/IFM**

We were able to schedule an additional training in partnership with UW Extension on Selling Produce to Wholesale Markets. This event has been promoted to over 160 local growers and over 60 local buyers. This event will provide information on how to sell to local buyers and will include a networking component for local buyers and producers.

V. Lessons Learned

Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project. Provide unexpected outcomes or results that were an effect of implementing this project. If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

1. **Reporting**.

Complete purchasing and promotional data was difficult to receive throughout the grant period. There were times we knew a BFBL partner would be eligible for an award but they would not submit all the relevant information. There were other times where we would have to micromanage the data collection process through providing promotional data for them (from their own facebook feed or from an event/promotion we hosted they participated in). Some who did report itemized local purchasing were surprised to see how much local purchasing they were actually doing. Our program provided the incentive they needed to quantify their purchasing. One partner proudly posted on social media they were purchasing 70% of their products from local sources!

We chose not to request receipts or proof or purchase from our BFBL partners since BFBL membership is contingent on local purchasing. This choice was made to make reporting less burdensome. In our data collection process we found it became easier to ask for an accountants purchasing report and that this had the added benefit of serving as receipt. Based on this and other timely consumer concerns about verifying local purchasing we will be updating our program procedures to request official purchasing reports.

2. **Incentives**.

We found that a cash incentive or reward motivated some to participate in our Restaurant Rewards program while others were motivated by the award or certificate. Many restaurants have prominently displayed their RR award in their restaurant from the foyer of Graze to the wall at Salvatore's Tomato Pies. Creating and promoting the award aspect of this program ended up being an important component and driver of participation.

3. **Target Audience.**
We piloted this program with a captive audience - our Buy Fresh Buy Local members. These members were often already excelling at local purchasing but the RR program gave us an opportunity to focus on produce and promotion. It was challenging to engage participation in this program outside of our BFBL partner group. We tried three different strategies, 1) creating a list of 25 ethnic restaurants and hand delivering an enrollment packet, 2) recruiting participants at the MidWest Foodservice Expo, and 3) joining the Latino Chamber Commerce. From this outreach one restaurant submitted an RR application and they were recruited from the MidWest Foodservice Expo. We will continue to build off of this outreach, and these relationships established during our RR program and hope to expand and recognize local purchasing in a more diverse group of restaurants.

We were also able to apply our work and resources from the RR program to our institutional partners including a partnership with the Wisconsin Healthy Hospitals network.

VI. Additional Information

Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Year two Restaurant Rewards facebook album: HERE
UW Extension post featuring Buying Local Produce guide HERE
REAP Food Group link to resource HERE (scroll to bottom of the page)
Selling Local Produce to Wholesale Markets registration link HERE (scroll to bottom of page)

Salvatore's Tomato Pies - facebook post below:

Qoute from South Dakota State University Extension Staff Member:
"I LOVE your resource guide "Buying Local Produce – A guide for Restaurants." We are just forming a food hub in southeastern South Dakota and are preparing for some chef receptions in the region to entice potential clients. I would like to use your guide, but be able to add in some South Dakota specific information instead of Wisconsin in some places. If you could give me permission to use your guide with local changes, I would gladly give you credit for the guidebook." - Kari O'Neil, Community Development Field Specialist, South Dakota State University

VIII. Contact Info:

Miriam Grunes
REAP Food Group
306 E Wilson Street, #2E
Madison, WI 53703
608-310-7836
miriamg@reapfoodgroup.org

12) Evaluating the susceptibility of cold hardy grape varieties to spotted wing drosophila (FY13-012)

Report Date: October 27, 2014

I. Project Summary

Spotted wing drosophila (SWD) is an emerging pest of soft-skinned fruit in Wisconsin with high levels of infestations reported in fall-bearing raspberries statewide in August and September 2012. SWD is known to infest grapes (and other fruits) in other SWD-positive states and the susceptibility of Wisconsin's cold hardy grape varieties remains unknown. The Upper Midwest wine and grape industry is rapidly growing due largely to the recent availability of several cold hardy grape varieties based on *Vitis riparia*, a cold hardy North American species. As these varieties are new and based on new genetics, there is very little research-based information about how new invasive pest species, such as SWD, will impact these grapes. While SWD infestations have been reported in vineyards in several states including California, Oregon, Washington, and New York, little information is available on the severity of infestations, varietal susceptibility, and the implications for cold climate grape varieties in the Upper Midwest. As wineries and grape fruit processors have a zero to low tolerance for insect larvae in fruit, Wisconsin grape growers recently named SWD as their top pest concern. As a result, there was and is a great regional demand from the wine and grape industry for research-based information.

This project evaluated the susceptibility of cold hardy grape varieties to SWD through determining varietal differences in performance of SWD and the correlation between SWD adult densities in trap catches and levels of fruit damage in vineyards. This project also provided grape growers with timely information through the Wisconsin Grape Grower Association newsletters and with field days and seminars on SWD identification, monitoring, and integrated pest management practices. A pre- and post-project survey addressed overall project impact by assessing growers acquired knowledge on identifying and monitoring SWD, on grape varietal susceptibility, and on the potential risks to their crop.

Our specific objectives were to: 1) evaluate the performance of spotted wing drosophila on cold climate grape varieties; 2) establish the correlation between SWD adult presence and fruit infestation/damage in cold climate grape varieties; and 3) provide reports, field days and present results to the wine and grape industry.

Current recommendations for managing SWD in soft fruit include applying insecticides on a 4-5 day interval from detection to harvest. The vast majority of grape growers practice IPM which is dependent on understanding where and when pests occur before taking management action. Understanding how to identify SWD, grape varietal susceptibility, and likelihood for SWD to successfully attack a fruit and for larvae to develop within it, will help grape growers make sound pest management decisions. The deliverable information from this project are 1) knowledge on the susceptibility of cold climate grape varieties to SWD; and 2) a more reliable approach for SWD monitoring and management. The recommended management approach resulting from this project deviates drastically from the current nationwide recommendations.

Based on our research, we recommend grape growers to NOT spray grapes when finding flies in their traps or on their fruit, but rather to check the fruit for the presence of larvae. Should larvae be found, growers should pick their fruit promptly and apply an insecticide if pre-harvest intervals can be observed.

B. This project did not build on any previous specialty crop block grant projects

II. Project Approach

All the work presented was conducted at commercial vineyards and informed by conversations with participating grape growers.

Objective 1: Evaluate performance of spotted wing drosophila on cold climate grape varieties. During September and October 2014, grapes from cold climate wine grape varieties, i.e. Marquette, Frontenac, Marechal Foch, La Crescent, St Pepin, Concord, St. Croix, Leon Millot, were harvested and assessed for their susceptibility to SWD in laboratory no-choice bioassays. Raspberry was used as a positive control. Both damaged and undamaged grapes were exposed to SWD adults and performance was measured as the number of eggs laid, number of larvae, number of adults emerged, and time to adult emergence. Fruit characteristics (Brix, pH, and titratable acidity) were assessed for each variety and correlated to preference and performance metrics. To minimize any effects of pesticide residues, fruit clusters were bagged using waterproof pollination bags starting in mid-July. Grapes were either undamaged (8-10 reps) or damaged (8-10 reps) with each replicate containing eight individual fruits. Stems were left on the grapes to prevent access of SWD adults to any damaged area created by removing the stem. Damage was created by cutting just below skin surface for a 10 mm long cut using a utility knife starting from the stem toward the grape's base. Ten additional replicates of eight red, store-bought organic raspberries were established as positive controls as they are known to be preferred hosts. Fruit was then exposed to adult SWD with five females (0-7 days old) and three males (0-7 days old) added to each of the cups. To ensure fruit samples were not previously infested, three additional cups of each grape variety and the raspberry control were established without the addition of flies. Rearing containers consisted of 355 ml clear plastic cups (Solo Cup, Lake Forest, Illinois, USA) with a fine mesh lid. All cups were placed in Percival I-36LLVLC8 growth chambers (Perry, Iowa, USA) with a 16:8 (L:D) photoperiod at 22˚ C.

After 48 hours, adults were removed from rearing cups using a vacuum aspirator. Five cups from each variety of grapes were assessed the same day under the microscope to count the number of eggs laid on each of the eight grapes. An egg was recorded if one or two breathing tube filaments were visible. Raspberries were not assessed because breathing tubes were not reliably visible, as noted in Lee et al. (2011). Six days after experiment initiation, half the fruits from each cup were dissected to determine the presence of larvae. Fruit was removed from cups and destructively sampled in order to count all present larvae (1st-3rd instar). The remaining four fruits were checked daily for emerged adults which were removed until the experiment was terminated at 21 days after initial adult removal. The following preference and performance metrics were taken during the experiment: number of eggs laid, number of larvae present, number of adults emerged, and development time (days from experiment initiation to adult emergence).

The results are presented in Table 1 and reveal that undamaged grapes of the selected varieties are not susceptible to SWD damage with very few eggs, larvae, and adults found in any variety. Overall, damaged fruit of any variety had more eggs, larvae, and adults than undamaged grapes, suggesting that damaged grapes are susceptible to SWD infestations.

In 2015, we assessed the susceptibility of selected table grape varieties based on conversations with grape growers in 2014. We selected Trollhaugen, Somerset, Delaware, Reliance, and Concord. Assays were conducted the same way as described above. Results are presented in Figure 1 for number of eggs, Figure 2 for larvae, and Figure 3 for adults. Undamaged grapes were not significantly different in the number of eggs between varieties (n= 5; F= 0.82; P=0.52). For damaged grapes, concord had more eggs than any other variety tested. Similarly, the number of larvae and adults was significant for the damaged grapes, with more larvae found in Concord and Reliance. Overall, the results suggest that damaged grapes are more susceptible than undamaged grapes. Similar to wine grapes, undamaged table grapes do not seem to be susceptible to SWD, with very few eggs, larvae and adults found. Overall, grapes are less susceptible than raspberry, the most preferred host for SWD.

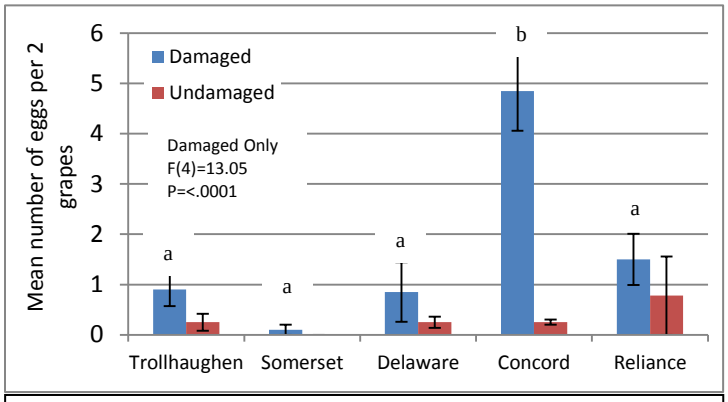


Fig 1. Mean number of eggs per 2 grapes for selected table grape varieties in no-choice tests.

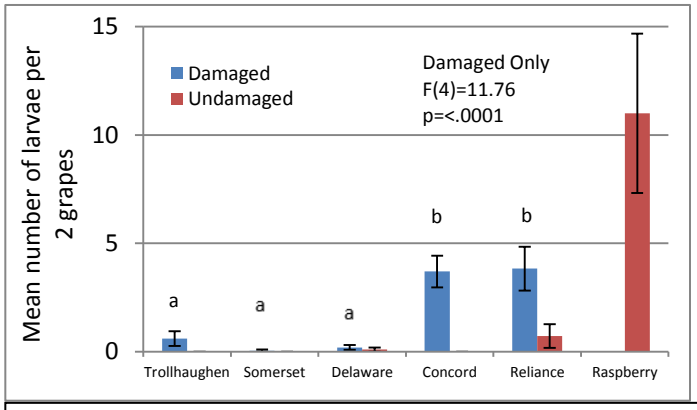


Fig 2. Mean number of larvae per 2 grapes for selected table grape varieties in no-choice tests.

Table 1. Mean number of eggs, larvae, adults, and development time from egg to adult emergence in days (± S.E.) of *D. suzukii* per gram of fruit for no-choice tests.

Treatment	Variety	Eggs	Larvae	Adults	Development time in days
Undamaged	La Crescent	0.17 (0.12) ab	0 (0) a	0 (0) a	--
	Marechal Foch	0.30 (0.05) ab	0 (0) a	0 (0) a	--
	Leon Millot	1.28 (0.81) ab	0 (0) a	0.03 (0.03) a	16.00 (0)
	St. Croix	0.16 (0.05) ab	0 (0) a	0.02 (0.02) a	14.00 (0)
	Marquette	1.07 (0.08) a	0 (0) a	0 (0) a	--
	Frontenac	0.45 (0.41) ab	0.02 (0.02) a	0 (0) a	--
	St. Pepin	0.01 (0.01) b	0 (0) a	0 (0) a	--
	Concord	0.02 (0.01) b	0 (0) a	0 (0) a	--
Control	Raspberry	--[1]	1.57 (0.32) b	1.35 (0.24) b	12.88 (0.04)
	Kruskal-Wallis	$\chi^2_{7} = 23.54$	$\chi^2_{8} = 77.70$	$\chi^2_{8} = 80.35$	--
		$p = 0.0014$	$p < 0.0001$	$p < 0.0001$	--
Damaged	La Crescent	3.85 (1.41) a	1.65 (0.49) ab	0.17 (0.13) a	16.71 (0.71) bc
	Marechal Foch	1.86 (0.67) a	1.15 (0.35) ab	0.32 (0.13) a	14.40 (0.21) bc
	Leon Millot	2.71 (0.70) a	2.08 (0.56) ab	0.47 (0.13) ab	14.89 (0.37) bc
	St. Croix	0.64 (0.30) a	0.60 (0.16) a	0.42 (0.16) ab	14.43 (0.23) c
	Marquette	2.67 (0.25) a	3.03 (0.60) b	0.77 (0.13) ab	16.61 (0.22) b
	Frontenac	2.28 (0.69) a	1.40 (0.55) ab	1.04 (0.28) ab	15.98 (0.21) bc
	St. Pepin	1.23 (0.61) a	1.53 (0.29) ab	0.80 (0.27) ab	15.63 (0.16) bc
	Concord	1.07 (0.21) a	1.37 (0.34) ab	0.81 (0.19) ab	16.48 (0.16) b
Control	Raspberry	--	1.57 (0.32) ab	1.35 (0.24) b	12.88 (0.04) a
	Kruskal-Wallis	$\chi^2_{7} = 13.76$	$\chi^2_{8} = 14.72$	$\chi^2_{8} = 25.66$	$\chi^2_{8} = 529.93$
		$p = 0.0555$	$p = 0.0649$	$p = 0.0012$	$p < 0.0001$

Different letters within a column indicated a significant difference between varieties at $p < 0.05$ (Tukey's HSD). [1] Raspberries were not assessed for eggs because breathing tubes were not reliably visible.

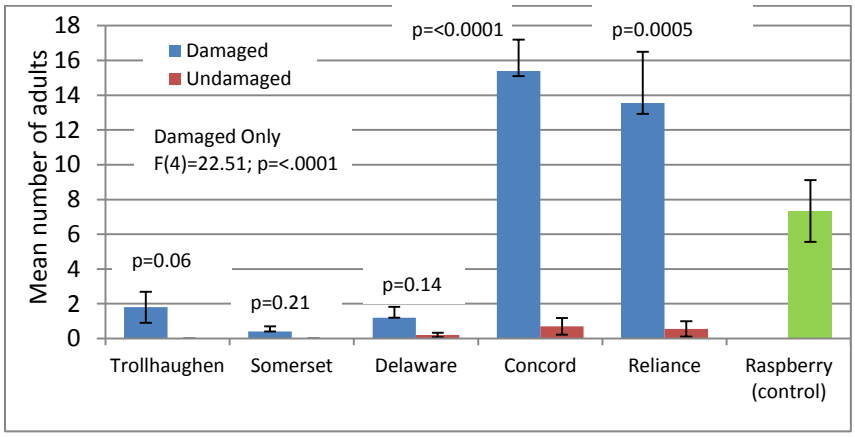


Fig 3. Mean number of adults emerged for selected table grape varieties in no-choice tests.

Objective 2: Establish the correlation between SWD adult presence and fruit infestation/damage in cold climate grape varieties.

During the 2014 growing season, field sampling was conducted to monitor adult populations by trapping with yeast-sugar bait to determine presence and abundance of flies in different grape varieties. Larval sampling was conducted using fruit-dunk tests to establish larval presence and abundance. Fruit samples were collected biweekly on bait-changing days from vines adjacent to monitoring traps until the first larva was found, then samples were collected weekly until harvest. Results are presented in table 2 and figure 4 and reveal that adult populations are found at all vineyards, averaging 42 to 142 adult per trap per week and are found throughout the season. Combining trap catches over the sampling period, Edelweiss had significantly higher adult trap catches than all other varieties except Frontenac (Table 2). Larvae were present in all varieties in at least one fruit sample, but presence and abundance was low, ranging from 0 to 4 larvae per kg of fruit on average (Table 1) out of a total of 151 samples. The abundance of larvae did not differ between varieties and did not correlate to adult trap catches.

Table 2. Mean *D. suzukii* adults and larvae (± S.E.) per week from mid-July through September 2014 in Southern Wisconsin vineyards.

	Adult sampling		Larval sampling	
Variety	Number of Vineyards	Mean (± S.E.) Adults	Number of Vineyards	Mean (± S.E.) Larvae/kg Fruit
Frontenac	3	81.88 (17.25) ab	4	1.92 (0.79) a
Marechal Foch	4	76.13 (12.65) a	4	3.60 (1.99) a
Marquette	4	41.77 (5.22) a	4	2.94 (1.26) a
La Crescent	3	58.21 (12.12) a	4	2.40 (1.66) a
St. Croix	4	52.06 (11.27) a	4	1.85 (1.07) a
Edelweiss	4	142.10 (25.43) b	4	0.56 (0.53) a
ANOVA		$F_{5, 173} = 6.005$ $p < 0.0001$		$F_{5, 144} = 0.515$ $p = 0.765$

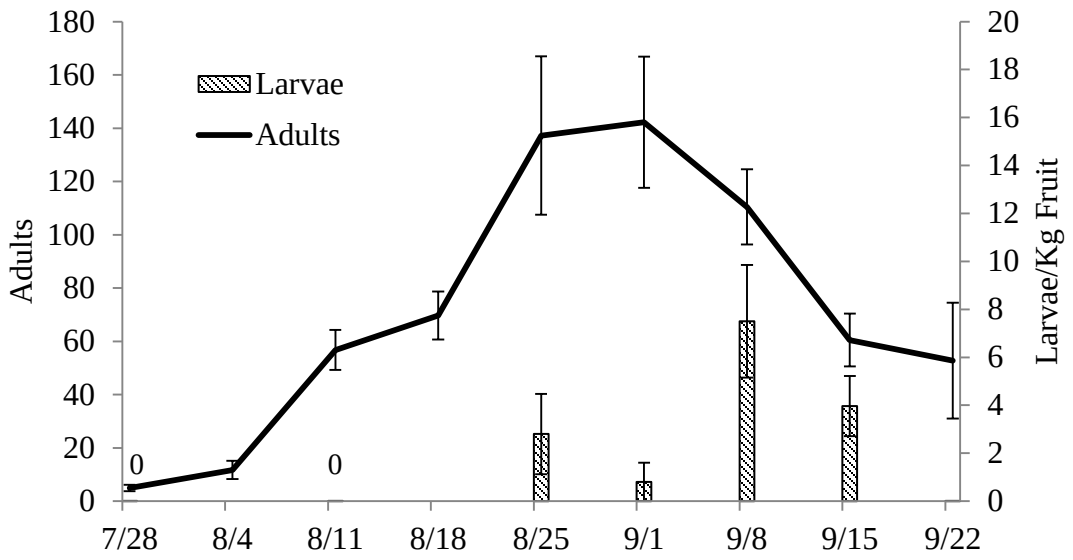


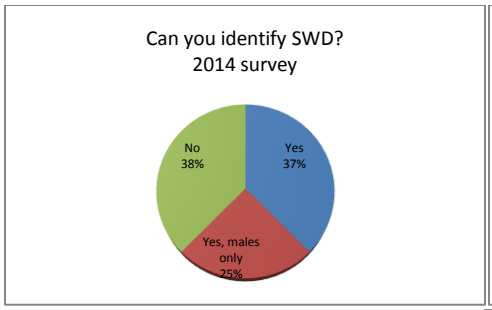
Figure 4. Mean SWD adults caught (± S.E.) per trap and mean number of larvae/kg fruit (± S.E.) phenology in six cold hardy grape varieties (Edelweiss, Frontenac, La Crescent, Marechal Foch, Marquette, and St. Croix) from mid-July through September 2014 in Southern Wisconsin vineyards.

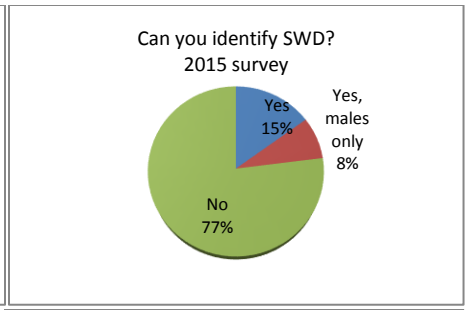
Objective 3: Provide reports, field days and present results to the wine and grape industry. Results were presented at the Wisconsin Fresh Fruits and Vegetable Conference in January 2015 and at vineyard walks in August and September 2015. Grape growers were regularly informed by emails to the WGGA of updates on SWD and on the SWD website.

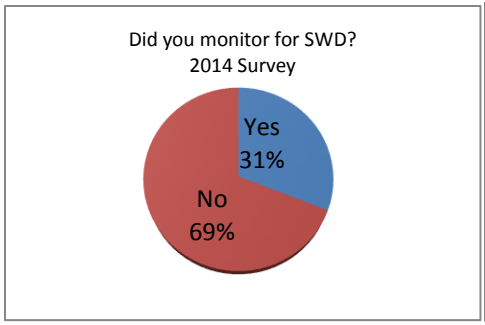
Impact on grower practices: Recommendations to grape growers in Wisconsin have been adjusted to reflect our research results. We now recommend to growers to monitor fruit for the presence of larvae as opposed to monitoring adult populations. We found that adult populations are pretty high in grapes although fruit infestation levels are extremely low. Thus monitoring for adults is not a good indication of fruit susceptibility and insecticidal sprays are not recommended unless larvae are found in the fruit.

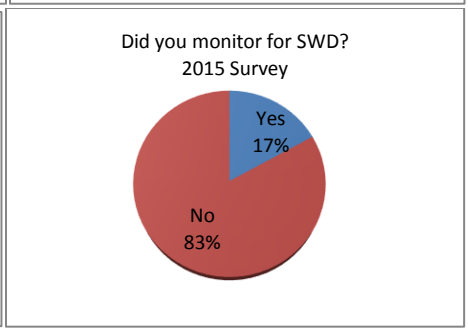
III. Goals and Outcomes Achieved

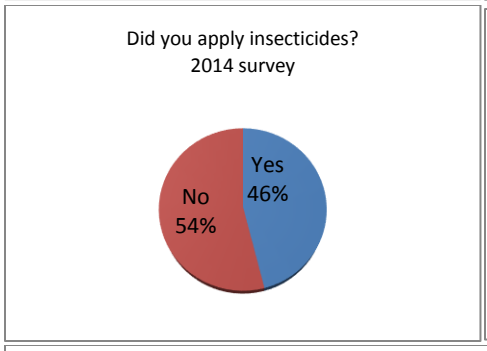
A. The activities completed include 1) evaluating the performance of SWD on cold climate grape varieties, 2) Establish the correlation between adult field populations and larval infestations; 3) Provide educational programming to grape and wine industries. All activities were performed and completed with additional tests being conducted with table grape varieties in 2015. The performance goals were measured through the surveys conducted with grape growers in 2014 (pre-project) and 2015 (post-project). Selected results from the surveys are presented below. In 2014, 16 growers participated in the survey and 18 in 2015. It is obvious from the first question presented that different people filled out the survey in 2014 than in 2015 and thus the results are not representing a direct impact of our research on grape growers' knowledge of SWD. Overall, grape growers seem less concerned about SWD and this could explain why fewer of them know how to identify the flies and monitor for the adults. A bigger sample size of growers surveyed would have helped in pulling out the impact of our research.

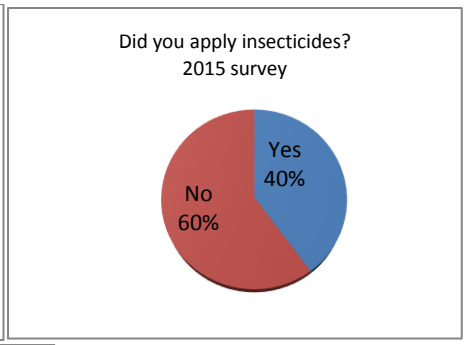


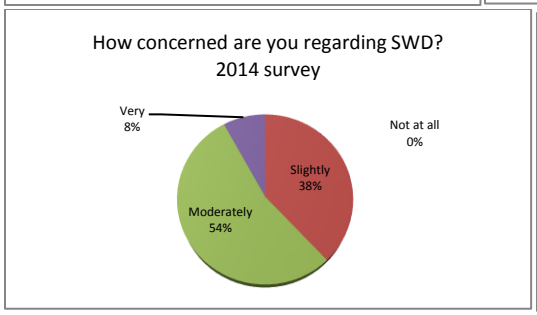


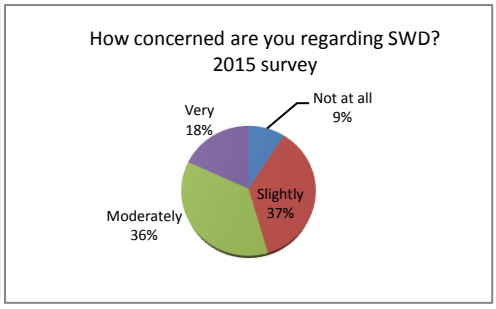












B. We accomplished every objective and activity we intended to do in the proposal. We were successful at assessing the susceptibility of cold hardy grapes grown in the Midwest to the new invasive fly spotted wing drosophila. We showed that the varieties tested are only slightly susceptible to SWD damage and management practices should be adjusted to reflect these results. As mentioned above, we now recommend to grape grower to ignore adult trap catches as we know that SWD adults are in all varieties and all vineyards assessed. Growers are advised to check their fruit for larval infestations before apply management practices, thus reducing the unnecessary use of insecticides to control SWD populations. We also advised growers that any crack found in fruit is an entry point for SWD females to lay their eggs in and thus care should be taken in harvesting fruit in a timely fashion to avoid skin cracking on varieties that are prone to skin cracking.

The one activity that we did not accomplish relates to measuring the skin thickness of the grapes. Despite our many attempts, we were not able to devise a method to measure this parameter and had to abandon collecting this data as fruit became compromised with aging.

We expect that growers will start implementing our recommendations and pay special attention to larval infestation before applying economically and environmentally costly management practices.

IV. Beneficiaries

The results of this study will directly benefit the wine and grape industries of the Upper Midwest, including Wisconsin. The wine grape industry is one of the fastest growing agricultural sectors in Wisconsin. There are almost 100 licensed wineries and 150-200 vineyards in the state. As many other soft skin fruits grown in Wisconsin including blackberry, raspberry, blueberry, cherry, and strawberry are susceptible to SWD infestation, these education efforts extend to other fruit growers and will improve general fruit grower knowledge of this pest.

V. Lessons Learned

Our lab and field assays were well conducted and the methods have helped us assess the susceptibility of other fruit crops as well. We found it impossible at this stage to test and correlate the skin thickness as we intended to do. We are still in the process of trying to figure this out as we think this is a major reason for the low susceptibility of cold hardy wine grapes.

VI. Additional Information

Recommendations for grape growers on how to manage SWD were provided on our SWD website http://labs.russell.wisc.edu/swd/. Newsletters were provided to grape growers during the season in 2014 and 2015 to inform them about SWD and reports of our research results were provided at vineyard walks in 2015.

VII. Contact Info

Christelle Guedot
College of Agriculture and Life Sciences
University Of Wisconsin - Madison
545 Russell Laboratories
1630 Linden Dr
Madison, WI 53706
(608) 262-0899
guedot@wisc.edu

13) Neonicotinoid use patterns in central sands (FY13-013)

Report Date: November 16, 2015

I. Project Summary

Most insecticides used for control of Colorado potato beetles (CPB) in the Northeast and Midwest US have failed because of resistance that has developed in populations of this problematic insect. Increasingly, growers rely heavily on a single class of insecticides called the neonicotinoids (i.e.: imidacloprid, thiamethoxam, clothianadin, dinotefuran) for control of CPB (NASS 2006). Imidacloprid resistance first appeared in NY in 1997, and is now common in the northeast and appeared in the Michigan in 2004 and in Wisconsin in 2007. Growers in these regions of the United States are experiencing serious control problems, including multiple locations in Maine, Michigan, and Wisconsin. This erosion of control with the neonicotinoids threatens the continued effectiveness of current CPB control programs and may seriously alter the economics of potato production. We now also know that the neonicotinoids have been detected in groundwater samples since 2008. The explanations for how these contaminations have occurred is unclear, and the association with particular use patterns of these water-soluble insecticides seems to be of critical importance for the state and the region and further investigation for more practical and long-term CPB control. Again, this project was developed from the outcomes of a related project originally funded by WI DATCP SCBG Program and funded in 2012. In the previous submission, a principal focus of the project focused on characterization of CPB insecticide resistance to the neonicotinoid class (IRAC, Group 4A) and the relationships between neonicotinoid use patterns (e.g. seed treatment, in-furrow, side-dress, or foliar applications) and the movement of neonicotinoids into the potato plants. A final focus of the grant attempted to document the potential for increased groundwater contamination resulting from various neonicotinoid use patterns. Taken together, we have begun these analyses to determine the spatial scale over which groundwater contaminations have occurred and if particular cropping systems are more closely associated with these detections. In total, the project purpose remains directed at further enhancing our present integrated pest management strategies for key insect pests in potato with a focus on the development of sustainable resistance management (IRM) practices to lower Colorado potato beetle (CPB) pest populations and limit the current and future potential for groundwater contamination.

Research Objective(s):

1) Assessment of CPB insensitivity to neonicotinoid insecticides within the state of Wisconsin and the upper Midwest Region.

2) Determine the relationship of insecticide use patterns and in-plant insecticide concentrations and plus the influence of insecticide use on neonicotinoid leaching.

3) Investigate the spatial scale of insecticide (neonicotinoid) contamination in groundwater using hierarchical sampling techniques.

B. Again, this project was developed from the outcomes of a related project originally funded by WI DATCP SCBG Program and funded in 2012. In the previous submission, a principal focus of the project focused on characterization of CPB insecticide resistance to the neonicotinoid class (IRAC, Group 4A) and the relationships between neonicotinoid use patterns (e.g. seed treatment, in-furrow, side-dress, or foliar applications) and the movement of neonicotinoids into the potato plants. A renewed focus of this project has been focused on determining the within plant distribution patterns of insecticides following different use patterns. In addition, the spatial extent of these insecticide groundwater contaminations is unclear and a focus of the grant attempted to document the potential for increased groundwater contamination resulting from various neonicotinoid use patterns.

II. Project Approach

Objective 1. Continued assessment of Colorado potato beetle insensitivity to neonicotinoid insecticides within Wisconsin was undertaken. In the 2013 year of this investigation, correspondence was maintained with University and Extension personnel, consultants, agrichemical representatives, and growers to identify and send in suspect populations for testing representing 1) potato seed production, 2) commercial potato production, and 3) sites where CPB populations were showing some level of insensitivity. In 2013, we continued resistance monitoring on a select number of fields in Wisconsin where neonicotinoid insensitivity is reportedly high. In particular, we collected adult beetles from both the 1st and 2nd generation from among 5 additional separate field locations in Wisconsin. Together with this assessment, we surveyed a total of 8 independent potato producers to inquire about the interval of control (days) that they obtain adequate control of the CPB since the neonicotinoids were first registered in 1995. From this survey, we were able to determine that the interval of effective control using the neonicotinoid insecticides has been reduced, on average, by almost 440 growing degree days – GDD, and we have learned the extent of different chemical classes used for the control of this problematic insect spanning several years of management (**Fig. 1**).

In the new part of this study, our primary aim was to uncover any genes that were involved in enhanced molecular breakdown or reduced penetration of the neonicotinoid insecticide, imidacloprid. Specifically, we attempted to determine if genes in select resistant populations were constitutively active or were differently expressed compared to a susceptible reference population. We composed a transcriptome of all the genes expressed in both resistant and susceptible populations using RNA extracted from field populations of beetles collected in 2013. This approach allowed us to observe gene regulation across both the susceptible and resistant populations collected from a similar geographic region and similar time points during the growing season. Site selection for these experimental populations was based upon prior knowledge gained from earlier LC50 bioassays together with newly collected LC50 estimates. This approach provided a strong foundation to choose from among several resistant populations in the Central Sands Region of Wisconsin previously identified as resistant over successive growing seasons.

Objective 2. Determine the relationship of insecticide use patterns and in-plant insecticide concentrations and further determine the influence of insecticide use on neonicotinoid leaching. In 2012-13, the in-plant distribution of the systemic neonicotinoid insecticides were characterized following different at-plant applications of application of thiamethoxam (Platinum 75SG 2.67 fl. oz ai/a) or imidacloprid (AdmirePro 7.0 fl. oz ai/a) plus a control class of

insecticides. Decaying titers of neonicotinoid insecticides in potato were very apparent as early as 43 days after planting and is very likely be linked to emerging resistance in populations of CPB. Consequences of declining insecticide titers are include an acceleration of CPB resistance due to sub-lethal doses. In 2013, we again performed similar treatment structure using at-plant systemic insecticides. Here again, leaf material will be collected weekly for up to ten consecutive weeks and leaflet samples will be taken from mid-canopy for later analysis. In-plant concentrations of thiamethoxam will again be assessed with competitive ELISA (enzyme-linked immunosorbant assay) available through Envirologix Inc, Portland, ME, imidacloprid kit, cat # 006; Beacon Analytical Systems Inc, Portland, ME, thiamethoxam plate, cat # CPP-022) and tests will be conducted according to the manufacturer's instructions. End-point absorbance of samples will be taken at 450 nm to determine insecticide concentration of each sample and these will be assessed with nested ANOVA (R-core).

Objective 3. Investigate the spatial scale of insecticide (neonicotinoid) contamination in groundwater using hierarchical sampling techniques.

Ecological patterns are created by processes acting over multiple spatial and temporal scales. By combining spatially explicit sampling with variance components models, the relative importance of spatial scale to overall variability can be determined. In the context of this proposal, we were very interested to learn about the spatial extent of neonicotinoid contamination in groundwater resources in the potato and processing vegetable production regions of the Central Sands. The majority of high capacity wells used for potato and processing vegetable production are distributed just west of the Johnstown Moraine in Central Wisconsin. In 2012, we conducted a preliminary survey of operating irrigation wells located within the concentration of irrigated vegetables in the Central Sands region. In 2013 and 2014, we employed a spatially structured experimental design in the Central Sands region to quantify variation in neonicotinoid detection across two spatial scales: 1) sites less than 3.5 km, and 2) sites greater than 15 km. Specifically, aggregate sites represent candidate sample sites (high capacity wells) within a 3.5 radius of each other. Sample sites representing the larger spatial scale of 15 km will be sampled between aggregate well clusters. At each of sample dates throughout the 2013-14 growing seasons, 1L water samples were taken from fully operational high capacity wells in each experimental site, with a total of 127 wells sampled per site total 90 wells each sample date. As described previously, water samples will be returned to the laboratory and the concentration of thiamethoxam was assessed using the competitive ELISA tests described previously. To determine the spatial scales of variation in neonicotinoid detection, we propose a hierarchical variance components model using a nested ANOVA with 4 levels of random effects: test region and well site nested within region (R-core). We will implement the model for both within and among well sites separately for each time period to determine whether spatial patterns of detection differ by time period. Similar patterns of detection among spatial scales over time periods would suggest that groundwater contamination of neonicotinoids is very uniform and independent of cropping history above ground. Conversely, dissimilar patterns would suggest that contaminations are very discrete in occurrence, and may well be linked to agricultural practices implemented on the landscape above the test wells.

III. Goals and Outcomes Achieved

Improvement of resistance management and environmental quality through fundamental and applied research in Wisconsin will provide the necessary incentive for growers to reinvest in reduced risk practices. Promotion of innovative groundwater management practices within the USDA and NRCS's Environmental Quality Incentive Program (EQIP) may further promote greater awareness and acceptance of these practices through economic incentives. With EQIP, potato growers experiencing elevated neonicotinoid resistance and insecticide loss may optimize pest management by adopting innovative management for greater farm profitability, resource conservation, environmental assessment, and biodiversity restoration. Proposed outcomes of our research are consistent with objectives of the U.S. Farm Bill which address pest management needs of the growers while working to limit non-target impacts to the environment. Moreover, the outcomes of the generated research has now begun to build a more comprehensive picture of the extent of neonicotinoid resistance in the upper Midwest production region, and the potential for neonicotinoid movement into groundwater resources, together with an assessment of the extent of off-site movement of selected neonicotinoids through a cluster analysis water-monitoring survey. Over the term of this proposal (2013-14), resistance monitoring was performed on a select number of 5 fields in Wisconsin where neonicotinoid insensitivity is reportedly high. In particular, we collected adult beetles from among 5 separate field locations in Wisconsin (**Table 1**).

Table 1. Parameter estimates of measured neonicotinoid (imidacloprid) resistance among five Colorado potato beetle populations in Wisconsin.

Population	Year[1]	N[2]	Slope(SEM)[3]	LC_{50} (PPM)	95% CI	Resistance Ratio[4]
Arlington	2013	400	2.23(.25)	0.09	(.08-.12)	NA
Hancock	2013	300	0.73(.23)	0.91	(.49-4.30)	10.11
systemic-1	2013	350	0.69(.26)	1.83	(.21-12.36)	18.18
systemic-2	2013	350	1.49(.37)	1.10	(.58-1.61)	11.11
systemic-3	2013	350	2.08(.30)	1.20	(.94-1.57)	12.12

[1]Sample year of testing
[2]Number of adult insects evaluated in topical bioassays
[3]Slope and associated standard errors associated with regressions of probit mortality and log dose
[4]Estimated resistance ratios calculated as the ratio of test population to the reference control strain (Arlington) populations.

With respect to our investigations into the molecular mechanisms of resistance in selected populations, these results are principally focused on gene expression in select CPB populations of the Central Sands Region of Wisconsin using RNA sequencing technologies. Expression studies were further validated with quantitative polymerase chain reaction (PCR). Based upon previous assessments of neonicotinoid resistance among populations in Wisconsin, we selected two candidate resistant populations and one nearby susceptible population to analyze in this study. This study uncovered many up-regulated genes in the two resistant populations that have the ability to combat insecticides in CPB. The two resistant populations showed some similarities in the up-regulated genes, but many of the up-regulated genes were differentially expressed between the two populations, suggesting that different populations of CPB may cope with insecticides in different manners.

Illumina sequencing was used to sequence mRNA collected from adult female CPB and subsequently assemble a transcriptome from the RNA sequencing data using Trinity bioinformatics software. A summary of data from the assembled transcriptome from RNA extracted from CPB populations is presented in **Table 2**. The transcriptome was composed of RNA isolated in 2013. RNA sequencing was performed on nine samples of pooled RNA, n=3 from each population (AARS, systemic-1 and systemic-3). The transcriptome revealed 98,002 possible unique transcripts for investigation and presumably some portion of these genes encode the aforementioned mechanisms of pesticide resistance. Subcomponents of Trinity were then grouped together and classified as individual components. From the 98,002 unique transcripts, we used 80,498 reference sequences from NCBI to identify 15,254 known transcripts in our transcriptome.

Table 2: Summary of Colorado potato beetle transcriptome assembled from the 2013 beetle populations collected from the Arlington Agricultural Research Station and two field populations, termed systemic-1 and systemic-3.

Summary of CPB transcriptome	
Total assembled bases	197,128,499
Total transcripts	208,754
Unique transcripts	98,002
median contig length	479
Average contig	944.41
Percent GC	36.49
Blastx hits(e value greater 0.001)	15,254

A novel goal of this study developed during the 2013-14 season was to investigate gene expression differences between the resistant and susceptible populations. From the 15,254 transcripts identified in the analysis, we chose to focus on genes associated with the known mechanisms of resistance. Specifically, we investigated changes in the expression levels of 10 classes of enzymes (cytochrome p450, glutathione related proteins, nicotinic acetylcholine receptors, ABC transporters, multi-drug resistance proteins, superoxide dismutase enzymes and catalase enzymes) to determine if patterns emerged in the up- or down-regulation of specific transcripts in the two resistant populations compared to the susceptible population. The transcriptome of CPB revealed 82 cytochrome p450s, 64 cuticular proteins, 18 glutathione related proteins, 12 carboxylesterases, 20 ABC transporter proteins, 4 superoxide dismutase enzymes, and 4 catalase enzymes. A portion of these may constitute possible resistance mechanisms (**Table 3**). The transcriptome also revealed 14 possible nAChRs, some of which are known targets of imidacloprid.

Table 3: Differentially expressed up- and down-regulated transcripts observed between two resistant populations compared to the Arlington Agricultural Research Station population.

	Whole Transcriptome	Systemic-1 Up-regulated	Systemic -1 Down-regulated	Systemic-3 Up-regulated	Systemic-3 Down-regulated
Total Transcripts	98,002	394	195	562	632
Total Transcripts with Blastx results evaluate(0.001)	15,254	265	69	370	348
Cytochrome p450	82	6	1	13	5
Cuticular	64	0	1	20	2
ABC transporters	20	3	0	5	0
Glutathione related proteins	18	1	0	1	0
Nicotinic acetylcholine receptor	12	0	0	0	0
Catalase	4	1	1	0	0
Multi drug resistance proteins	16	1	0	2	0
Superoxide dismutase	4	1	0	0	0
Carboxylesterase	12	1	0	2	0

Gene expression was compared between the susceptible population located the Arlington Agricultural experiment Station (AARS) and two of the three previously described resistant populations from agricultural fields (systemic -1 and -3). For the comparison, we used two pooled samples (biological replicates) of adult CPB collected from the second generation (mid-July collections) from each field. After the transcriptome was assembled, we calculated fragments per kilobase of exon per million fragments mapped (FPKM) of each sample and calculated the false discovery rate (FDR) between the populations. Gene regulation between the susceptible AARS population and the two resistant field populations (syestemic-1, syestemic-3) can be seen in **Table 3**. In the systemic-1 population there were a total of 394 transcripts, of which 265 share homology to known proteins. In the systemic-3 population, there were 562 transcripts, of which 370 share homology to known proteins.

An additional extension outcome will be an increased level of resistance management adoption at the level of 50%. We have used survey methods to document that growers, land managers, and pest management practitioners have reached, or exceeded, their resistance management targets. Specifically, we coordinated these surveys through the Wisconsin Potato and Vegetable Growers Association, Annual Grower Education Conference held in Stevens Point, WI February 2013 and the outcome of their Environmental Impact Quotient scores are provided (**Fig. 1**).

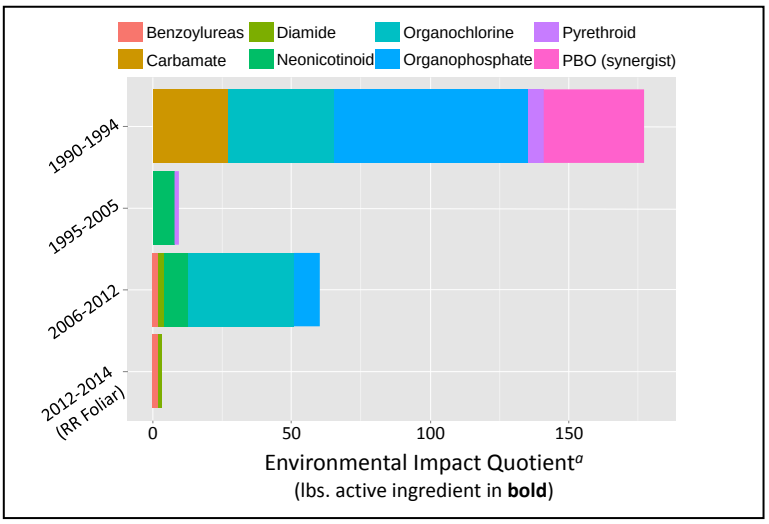


Figure 1. Environmental impact quotient estimates associated with periods of elevated levels of Colorado potato beetle resistance to insecticides in the discrete time frames (1990-94) and again (2006-2012). Prevailing insecticide resistance issues in each time frame resulted from synthetic pyrethroid and neonicotinoid insensitivity, respectively.

To determine the impact of different insecticide delivery treatments on thiamethoxam leachate detected over time, we reported the mean concentration over a period of several months (**Fig. 2**).

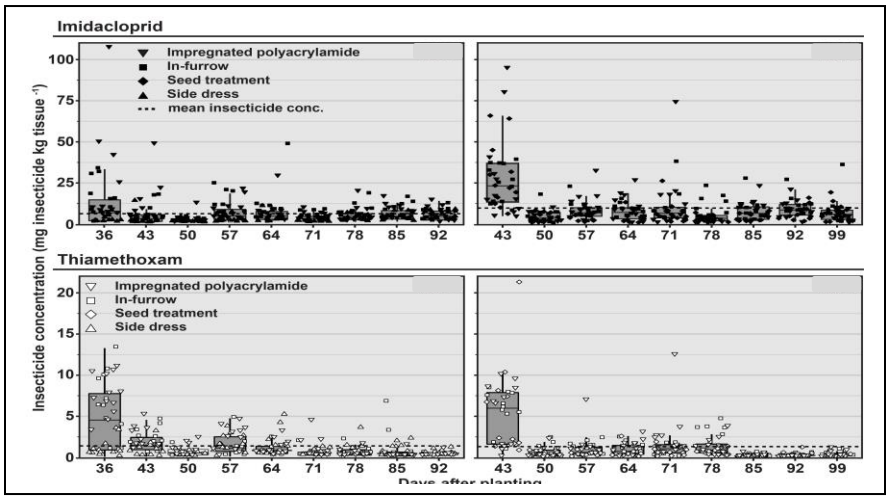


Figure 2. Thiamethoxam and imidacloprid concentrations in potato leaf tissue over time post planting. Average thiamethoxam and imidacloprid (±SD) recovered from different treatments in (A) 2012 an (B) 2013.

The neonicotinoid insecticides thiamethoxam and imidacloprid were included in field experiments to investigate the in-plant concentrations associated with different types of pesticide delivery. We hypothesized that thiamethoxam would be most vulnerable to leaching early in the season when plants were small and episodic heavy rains can be common. Interestingly, we observed the greatest insecticide concentrations were present in the imidacloprid treatments **(Fig. 2)**. Detections of thiamethoxam in plants varied between treatments through time in both years of the study (treatment x day interaction). Moreover, the impregnated polyacrylamide delivery produced the greatest amount of thiamethoxam concentrations late in each growing season (**Fig. 2**) when compared with other types of insecticide delivery.

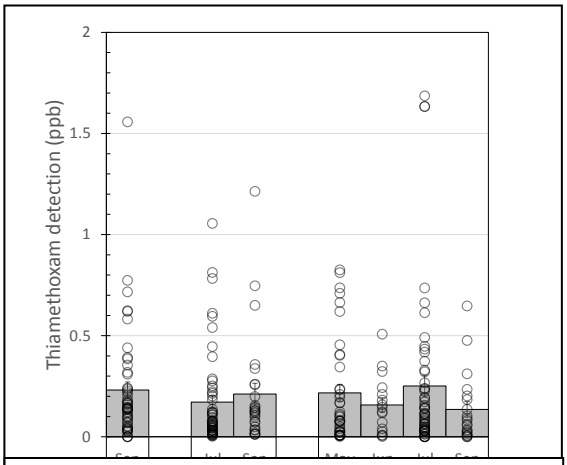


Figure 3. Well sample summary detection levels for thiamethoxam over the 2013-2015.

Summary of thiamethoxam well detections in Wisconsin over the two year period of the grant with the addition of the 2015 survey season reveals consistent insecticide detections across all spatial scales evaluated (**Fig. 3**). Detections of thiamethoxam averaged between 0.14 – 0.25 ppb across the range of 127 well samples evaluated. A total of 48 unique operating irrigation wells were evaluated in 2013 and another 79 were evaluated in 2014. Each well was sampled between 2 to 6 times during the production season for the total of 254 unique well samples. The highest overall detections recorded did not exceed 1.75 ppb at

any time or locale. The majority of these well detections remained well below the average detection levels recorded by the WI DATCP.

B. Experimental results were presented through the horticultural crops Extension Entomology program via field days (2013 and 2014, Hancock Potato Field Days), the vegetable extension newsletter (http://www.plantpath.wisc.edu/vegetable-newsletter-supplement-3-released), and formal conference presentations including the WPVGA Grower Education Conference in both 2013 and 2014. Research results were also published in the scientific literature through a combination of research venues as follows:

- Clements, J., Schoville, S., Peterson, N., Lan, Q. and Groves, R.L. 2014. Characterizing Molecular Mechanisms of Imidacloprid Resistance in Select Populations of *Leptinotarsa decemlineata* in the Central Sands Region of Wisconsin. PLoS ONE (accepted for publication 13 October 2015).

- Huseth, A.S., Groves, R.L., Chapman, S.A., Alyokhin, A., Kuhar, T.P., McRae, I.V., Szendrei, Z. and Nault, B.A. 2014. Managing Colorado Potato Beetle Insecticide Resistance: New Tools and Strategies for the Next Decade of Pest Control in Potato. J. Integ. Pest Mgmt. 5(4):http://dx.doi.org/10.1603/IPM14009.

- Huseth A.S. and Groves, R.L. 2014. Environmental Fate of Soil Applied Neonicotinoid Insecticides in an Irrigated Potato Agroecosystem. PLoS ONE 9(5): e97081. http://doi:10.1371/journal.pone.0097081.

- Huseth, A.S., Lindholm, J., Groves, C.L., and Groves, R.L. 2014. Variable concentration of soil-applied insecticides in potato over time: implications for management of Leptinotarsa decemlineata. Pest Mgmt. Sci. 70:1863-1871.

IV. Beneficiaries

Research objectives outlined in this study benefitted agricultural producers, crop consultants, University of Wisconsin Specialists and County Educators, and other stakeholders and have been essential for properly timing insect population control measures and further limiting environmental contamination. The proposed project was submitted and supported by the Wisconsin Potato and Vegetable Growers Association (WPVGA). The mission of the WPVGA is to assist members to be successful through education, information, environmentally sound research, promotion, government action, and involvement. The WPVGA has directly coordinated the execution of the sub-contracted research with the University of Wisconsin in support of the research and funding. Moreover, they have worked closely with each participating program and monitor progress throughout the term of the granting period. Preliminary reports from this research have been presented at the annual meeting in Stevens Point, WI in February 2013 and 2014. A more comprehensive and sustainable management approach to document the potential for insecticide movement into, and throughout plants, as well as leachate moving through the soil column is designed to increase the sustainability of the potato and processing vegetable industry in this ecologically important region of Wisconsin. The proposed goals and expected outcomes outlined herein are fully supported by the Wisconsin Potato and Vegetable

Growers. The producers of potatoes in the State of Wisconsin are immediate benefactors of this research to learn about tools of insecticide delivery that may limit offsite movement. Other basic researchers are also direct benefactors of this research to describe sources of environmental contamination in groundwater resources. Finally, natural resource conservationists are an obvious and additional set of benefactors of this information.

V. Lessons Learned

- In Wisconsin, high intensity potato production has generated stable populations of CPB that are capable of annual economic damage to the crop. As a result, growers have adopted pest management plans largely based on the use of a systemic insecticide to control these recurrent, early season infestations of CPB. For the past 18 years, soil-applied neonicotinoid insecticides have been the backbone of insect management, and this recurring use has resulted in resistance to these compounds. Over a period of five years, we observed a considerable increase in the number of growers reporting loss of efficacy of neonicotinoids. Other studies conducted in intensive potato production areas of the East Coast and Midwest have reported similar losses in levels of control associated with the use of the systemic neonicotinoids.

- We uncovered potential genes responsible for imidacloprid resistance in spatially explicit CPB populations in the Central Sands region of Wisconsin. We used knowledge acquired from dose-response generated regression estimates that were calculated in 2013 and 2014, to identify 2 candidate imidacloprid resistant field populations and a single susceptible population. With this data, we attempted to establish the mode of imidacloprid resistance within these selected populations of CPB by uncovering genes that were differentially expressed in association with imidacloprid exposure. We found that both of the resistant populations investigated had many up-regulated genes that were constitutively activated, including many cytochrome p450s. Interestingly cuticular proteins were found up-regulated in only the systemic-3 population. One limitation of this study is that it did not integrate the effects that other pesticides and environmental stressors have had on beetles. It is possible that some of the genes that are being up-regulated are the product of other stressors. We chose to use field populations of CPB to examine relevant field conditions that give rise to insecticide resistance that farmers face.

- In this study, we observed high concentrations of neonicotinoid insecticides in potato foliage within two weeks of crop emergence followed by a sharp decline as the season progressed. Similar patterns in soil-applied insecticide concentrations have been documented for several different application methods (e.g. seed, in-furrow, drip, and drench) in other annual herbaceous crops as well as perennial tree, shrub, and vine crops. This rapid reduction in concentration is intriguing as these declines closely correspond with expansion of the potato canopy in early June. Other studies in annual crops seldom indicate the potential of rapid plant growth as a factor affecting the dilution of concentrations of the insecticide. Reduction in the concentrations of these insecticides at the time of canopy expansion increases crop vulnerability to direct damage by insect herbivores and also increases the potential for pathogen transmission. Furthermore, the non-uniform distribution of systemic insecticides in (among and likely within) plants

creates the potential for refugia to be present within both within and among plants resulting in increased selection pressure for accelerated insecticide resistance development later in the season.

- Major rainfall events did not significantly influence detections of neonicotinoids in the experimental area. Early season rainfall was not exceptionally heavy in either year of this experiment. The accumulation of leachate detections in lysimeters likely is reflected by the steady application of irrigation water and rainfall. One clear exception to this pattern occurred in 2012 at 155-156 days after planting when 89 mm of rain fell within a 24-hour period. Peak detections of thiamethoxam in 2012 began to trend upward following this rain event, however the timing of similar detections across treatments in 2011 occurred at about the same time. One additional explanation may be that increased levels of pesticide losses are associated with plant death or senescence.

- In each year of this study, the largest proportion of pesticide detections in leachate occurred shortly after vine killing in potato. Vine killing in commercial potato production is a common practice designed to aid the tubers in developing a periderm. Perhaps the rapid loss in root function following plant death permits excess pesticide to be solubilized and washed through the soil profile more quickly in root channels. In both seasons of this study, however, large episodic rain events did not occur early in the growing season. These results do appear, however, to document low to moderate levels of leaching losses that occur throughout the season even when the crop is managed at nominal evapo-transpirative need.

- Untreated control plots also yielded low-level detections of thiamethoxam throughout both seasons. To better understand these insecticide detections in control plots, we sampled water directly from the center pivot irrigation system providing irrigation directly to the potato crop. Samples were taken while the systems were operational from lateral spigots mounted on the well casings. In both years, samples revealed low concentrations of thiamethoxam present in the groundwater at two time points in each sample season from which irrigation water was being drawn. Clothianidin was also present at a single time point in 2012. These positive detections of low-dose thiamethoxam were obviously being unintentionally applied directly to the crop through irrigation and this information is new to the producers in the Central Sands of Wisconsin. Although systemic neonicotinoids have recently been detected from surface water runoff and catch basins associated with irrigated orchards, to our knowledge no other study has documented the occurrence of neonicotinoids in sub-surface groundwater being recycled through operating irrigation wells.

- Two alternative delivery methods, the side dress and impregnated polyacrylamide treatments, were included in these investigations to determine if the duration of high insecticide concentrations could be extended further into the growing season. Side dress applications were once common with older systemic compounds such as disulfoton (Di-Syston® 15G, Bayer Cropscience, Research Triangle Park, NC) and aldicarb (Temik® 15G, Bayer Cropscience, Research Triangle Park, NC), but have since been discontinued with registration of in-furrow neonicotinoids and voluntary cancellations. In our study,

full rate, side dress applications of neonicotinoids showed little benefit in extending the interval of insect control or increase in the residual concentrations of insecticides in the plant. We observed an overall reduction in the residual concentration of both active ingredients associated with the side dress use pattern. However, this study documents that side dress application methods did not result in increased insecticide concentration during the growing season and no statistical increase in control of CPB when compared with other common soil-application methods.

- Here we found that regardless of the soil application method or neonicotinoid used, insecticides lost efficacy through time, but were still detectible in plant tissues at the conclusion of the study. Under commercial circumstances, growers would make additional foliar applications based on the insect population density and associated defoliation thresholds. For the insect population, multiple modes of action would be operating as a simultaneous selection factor for insecticide resistance within discrete CPB generations. Consideration of the manner in which insecticides are delivered, residual time of each compound, and exposure of to the target pest are all critical components in sound resistance management plans. Sub-lethal, chronic exposures from early season soil-applied insecticides, independent of mode of action class, should be carefully evaluated as a possible contributor to emergence of insecticide resistance selection. Results of this study improve our understanding about the effects of different insecticide delivery methods on in-plant plant concentration profiles through time and the effects of measured pesticide concentrations on CPB.

VI. Additional Information

None to report here

VII. Contact Info

Tamas Houlihan
Executive Director
Wisconsin Potato Industry Board
P.O. Box 327
Antigo, WI 54409
715-623-7683
thoulihan@wisconsinpotatoes.com

14) Using a Novel Cover Crop Blend to Increase the Sustainability of Ornamental Plant Nursery Production (FY13-014)

Report Date: October 27, 2016

I. Project Summary

A. Standard nursery ornamental tree production is conducted in fields maintained by extensive use of mechanical (tillage) and chemical (herbicide) inputs. Not only is this costly and labor-intensive, but multiple passes over fields results in soil compaction and formation of deep plow layers that impede drainage and root growth, and the absence of plant cover leads to soil erosion.

Cover crops are a logical means of increasing sustainability, however studies have shown that the highly-competitive cover crops traditionally used in agronomic settings (e.g. buckwheat, winter rye, perennial ryegrass and trefoil) can reduce nursery crop growth. The tillage radish (*Raphanus sativus*), a relatively new cover crop to the U.S., is being used in agronomic settings to reduce soil compaction, hold nutrients, limit runoff, and reduce herbicide applications during the winter months. The ability to aerate the soil well below compacted plow layers has intrigued farmers and opened the avenue for uses in other industries, including perennial plant nurseries. However, the use of tillage radish as a cover crop in nursery settings has yet to be tested in a controlled, replicated production setting. In addition, combining the annual tillage radish with a perennial such as red clover (*Trifolium pratense*) offers the opportunity for a single seeding pass to provide cover crop for the duration of a multi-year crop such as those in woody plant nurseries, where the perennial clover establishes during tillage radish growth and fills-in the following season after the radish has died.

This project studied whether a cover crop blend consisting of the annual tillage radish and the perennial red clover provided the desired increases in efficiency and environmental sustainability. It was hoped that, if proven successful, this approach could be readily expanded to many other field production activities involving long-term perennial crops.

B. This project did not build on a previously funded Specialty Crop Block Grant

II. Project Approach

Three types of trees were lined-out in fields prepared using standard nursery practices: honeylocust (*Gleditsia triacanthos* var. *inermis* 'Skyline'), oak (*Quercus* spp.) and Colorado spruce (*Picea glauca*). The cover crop blend consisting of the annual tillage radish and perennial red clover was sown in late August into September. Seeds were sown in a single pass using a rear mounted Land Pride Primary Seeder (drop seeder with packer rollers) with light soil agitation from belly mounted cultivators. Both the tillage radish and clover germinated and grew well, with the clover establishing beneath the tillage radish during the first season then filled-in the following season after the radish has died (Figure 1).

Standard weed control practices (fertilizer banding, weed and pest control) were employed in the control plots throughout the duration of the project. Visual assessments of overall tree appearance and weed pressure were performed annually in late summer.

Figure 1. Tiller radish (*Raphanus sativus*) during the first season (left). Cover crop during first winter (right). Established clover (*Trifolium pratense*) can be seen beneath decaying radishes. An unexpected finding of this study was that the development of honeylocust canker (*Nectria* spp.) infection was greatly reduced in the cover crop plot (5% infection vs 94% infection in the control plot managed using tradition weed control measures) (Table 1). It is believed that these trees arrived from a west-coast producer with the canker fungi already present, and environmental differences between the treatments effected the trees' susceptibility to canker symptom development. Because of this issue and production shortages in other fields resulting from damage by this canker, the honeylocust were harvested ahead of schedule and were not available for further analysis.

Honeylocust-Control			
Size	Number Trees	Number with Canker	% Canker
5-6 Whip	244	229	94%
7' Whip	177	8	5%
Honeylocust-Cover Crop			
Size	Number Trees	Number with Canker	% Canker
5-6 Whip	256	14	5%
7' Whip	400	13	3%

Table 1. Appearance of honeylocust canker (*Nectria* spp.) in the control and cover crop plots.

While statistically significant differences in chlorophyll content between the honeylocust control and treatment plots were found in 2014 (Table 2), it is now believed that this is an artifact related to the effect of the disease and not the direct result of the cover crop treatment. Chlorophyll content measurements of four oak species and the spruce did not reveal any statistically significant differences between the cover crop and control treatments.

Treatment	Chlorophyll Content (mg/m^2)	P-value
Honeylocust 2014		
Cover Crop	536.0	-
Control	583.3	0.046
Oak* 2015		
Cover Crop	683.7	-
Control	702.1	0.993
Oak* 2016		
Cover Crop	732.2	-
Control	722.4	0.862
White Spruce 2015		
Cover Crop	419.3	-
Control	357.1	0.486
White Spruce 2016		
Cover Crop	401.5	-
Control	365.7	0.557

Table 2. Chlorophyll content (mg/m^2) in cover crop and control plots for three tree species, honeylocust (*Gleditsia triacanthos* var. *inermis* 'Skyline'), oak (*Quercus* spp.) and White spruce (*Picea glauca*).

Means are significantly different at P-values ≤ 0.05. *Data for the four oak species is combined due to the high P-values within the data sets.

Caliper measurements taken on the oaks after two years of growth showed greater average caliper size for all four species in the cover crop plots vs the control plot (Table 3), with statistically significant differences within the swamp white oaks, and low P-values for both the Regal Prince and pin oak that are very close to significance. This is unlike previous studies that found reduced growth in production fields using other species of cover crops. This is another important finding, since reduced growth has been one of the major barriers to the widespread use of cover crops in the nursery industry. Caliper data for honeylocust was skewed due to the high incidence of canker and subsequent early harvest in the control plots and is therefore not reported. Height measurements of the spruce showed a slight, but not statistically significant, increase in the cover crop plot (Table 4).

Treatment	Mean Caliper	P-value*
Regal Prince Oak		
Control	1.72”	-
Cover Crop	1.92”	0.084
White Oak		
Control	1.79”	-
Cover Crop	1.94”	0.295
Pin Oak		
Control	1.57”	-
Cover Crop	1.78”	0.077
Swamp White Oak		
Control	1.56”	-
Cover Crop	1.94”	0.028

Table 3. Mean second-year caliper data for four oak species (*Quercus* x ‘Regal Prince’, *Q. alba*, *Q. palustris* and *Q. bicolor*) in the control and cover crop plots. *Means are significantly different at P-values ≤ 0.05.

Treatment	Mean Height (Inches)	P-value*
White Spruce		
Control	28.0”	-
Cover Crop	27.3”	0.98

Table 4. Mean second-year height for white spruce (Picea glauca) in the control and cover crop plots. *Means are significantly different at P-values ≤ 0.05.

Visual assessments of overall tree appearance and weed pressure for the first two years of the four oak species revealed two interesting findings (Table 5). First, that overall tree appearance was higher for all species in both years, which is commensurate with the improved tree growth in the cover crop plots as indicated by caliper data. Second, while the cover crop plots displayed reduced weed pressure during the first full growing season, in the second year weed pressure was similar for both treatments. This was primarily due to the poor persistence of red clover in the second year, which allowed for much greater weed germination and growth. In our later work that is continuing beyond this grant period, and we have alleviated this problem by replacing the red clover with white Dutch clover, which so far has proven reliable through multiple growing seasons. Appearance assessments of the spruce were slightly better in the cover crop plots, and weed pressure in both the control and cover crop plots was high due to competition from volunteer winter wheat that carried-over from the previous season. The spruce were also smaller than normal when planted, which resulted in greater susceptibility to competition from the wheat, cover crop and weeds. This made it difficult to control weeds, often leading to hand mechanical cultivation (hoeing) that increased maintenance costs.

Treatment	Mean Appearance (1-5)	Weed Pressure (1-5)
Regal Prince Oak		
2015 Control	3.7	5
Cover Crop	4.6	1.4
2016 Control	4.1	5
Cover Crop	5	4
White Oak		
2015 Control	4	4.5
Cover Crop	4.9	3
2016 Control	4.2	5
Cover Crop	5	4.3
Pin Oak		
2015 Control	3.3	3.4
Cover Crop	3.9	3
2016 Control	4	5
Cover Crop	4.7	5
Swamp White Oak		
2015 Control	2.9	5
Cover Crop	3.6	2
2016 Control	4	5
Cover Crop	4.75	4.6
White Spruce		
2016 Control	4.5	5
Cover Crop	4.7	5

Table 5. Mean second-year visual assessment of overall tree appearance and weed pressure for four oak species (*Quercus* x 'Regal Prince', *Q. alba*, *Q. palustris* and *Q. bicolor*) in the control and cover crop plots.

The environmental benefits of incorporating cover crops into nursery field production are more difficult to quantify, especially in the relatively short time-frame of this grant period. While soil samples were collected from the plots for each of the three years of this study, no clear differences were observed, a result of both the slow-changing nature of soil characteristics and the inherent variability within our research plots. However, we are confident that soil improvements such as reduced compaction, and increased organic matter and nutrients will become evident over time. In fact, the superior growth and appearance of trees in the cover crop plots is likely an indirect measure of improved environmental conditions. In addition, we have observed markedly reduced erosion in the cover crop plots relative to the control plots where herbicides reduced the amount of biomass between rows (Figure 2).

Figure 2. Soil erosion in the honeylocust control plot.

Our cost analysis showed that over the first two years total costs of the cover crop treatments averaged $130/acre vs $250/acre for traditional nursery practices in the control plots. In addition, the cover crop created a working surface that improved the efficiency of production tasks such as pruning, suckering and harvesting, especially in wet weather conditions, and produced a more agreeable working environment for crews. The cover crop also buffered the effects of production equipment on the soil, which under traditional nursery practices often contributes to soil compaction and/or erosion.

In summary, the data provided by this study reveal the great potential of this cover crop blend in nursery production. The cover crop treatments proved to have a lower total cost per acre, and provided numerous benefits, including environmental (reduced erosion and lower chemical inputs), plant health (reduced disease and overall improved plant growth and appearance) and nursery production (working surface amenable to trimming and digging crews). This clear demonstration of the benefits of this cover crop blend should contribute to cover crops becoming standard practice in the nursery industry, leading to greater sustainability of this important industry.

There were two contributing partners to this project. Dr. Hoch collected the chlorophyll data, and analyzed this and other relevant data collected throughout the project. He also visited the test plots a total of 17 times during the project and helped in preparation of the final report. Dr. McCown visited the test plots a total of six times during the project, contributing to the assessments of the overall progress of the project, and in particular evaluation of the condition of the nursery stock and cover crops, and weed pressure in the control plots.

III. Goals and Outcomes Achieved

A. A variety of outreach activities were performed throughout the granting period, and will carry on well beyond this grant as the long-term benefits of this practice continue to emerge.

Outreach activities to date include:
- McKay Nursery hosted the International Plant Propagators Society Eastern Region Area meetings on July 16th, 2015, where the cover crop project was featured in a presentation and field tour. The area meeting was deemed a success with 28 industry attendees' participating in both a presentation and a field demonstration. Of the 28 participants, 24 expressed strong interest in the cover crop project.

- The social media presence of this study was also expanded on the McKay nursery website (http://www.mckaynursery.com/about-us/production.html) and on Facebook.

- An article featuring McKay Nursery's testing of this novel cover crop blend was published in the May 2016 issue of Nursery Management, a major industry trade magazine with over 16,000 print and digital subscribers.

- McKay Nursery hosted the 2016 Wisconsin Nursery and landscape Association Winter Workshop, where a presentation and field tour on the use of this cover crop blend were given to the 85 participants.

- Poster presentation entitled "Using a Novel Cover Crop Blend to Increase the Sustainability of Ornamental Plant Nursery Production". International Plant Propagators Society Eastern Region Conference, Hartford, Connecticut, September 21-24, 2016.

- Abstract in the International Plant Propagators Society Combined Proceedings, 2016. "Using a Novel Cover Crop Blend to Increase the Sustainability of Ornamental Plant Nursery Production". Vol. 66. *In Press*.

B. The Goal of this project was to increase the number of nurseries incorporating this combination of cover crops into their field production cycle, with a target of 10 nurseries beginning to use this combination of cover crops in their field operations. Although formal and informal surveys taken after outreach efforts were very positive, it will be difficult to identify changes in production practices for the over 600 nursery growers in Wisconsin. Although our direct-contact outreach efforts have only reached a small percentage of these growers, we do not know the impact of our media/web-based outreach. To date we are aware of two Midwest nurseries (Kankakee Nursery, Aroma Park, IL and Johnson's Nursery, Menomonee Falls, WI) that have already begun to use this cover crop blend in their field production. As this work continues and our long-term data expands, we plan on increasing our media outreach.

IV. Beneficiaries

As the use of this cover crop blend become widely accepted and the long-term benefits more apparent, we anticipate a large portion of the 616 nursery growers in Wisconsin to begin incorporation of this cover crop into their field production practices. A rough estimate of the

production cost savings observed during this study extrapolated to the over 14,000 acres of nursery production in Wisconsin results in an estimated annual savings of over one-half million dollars to state growers. In addition, this calculation does not include the environmental benefits to soil (reduced compaction and erosion, and increased organic matter and nutrients), reduced pesticide and petroleum use, and increased biomass for beneficial fauna, including pollinators. Furthermore, the findings of this study have application well beyond the Midwest, potentially contributing to the use of this and other yet-to-be developed cover crop blends as standard practice in many of the over 5,900 U.S. nursery growers. This would not only lead to improved production efficiencies and cost savings, but also provide the associated environmental benefits to over 900,000 acres nationwide that are currently under standard nursery production practices.

V. Lessons Learned

An important finding that resulted from our continued work on cover crops beyond this grant is that the red clover used in the grant-funded work demonstrated relatively low persistence beyond the second season, which allowed for greater weed pressure in long-duration crops. In later plantings we tested white Dutch clover in place of the red clover, which has proven to be more persistent through multiple growing seasons.

VI. Additional Information

VIII. Contact Info:

Thomas Buechel
McKay Nursery
P.O. Box 185
750 S Monroe Street
Waterloo, WI 53594
920-478-2121
tbuechel@mckaynursery.com

15) GAP/GHP cost share (FY13-015)

Report Date: November 7, 2016

I. Project Summary

A. The purpose of this project was to provide food safety assistance to Wisconsin-based specialty crop producers and processors, and to promote the Good Agricultural Practices/Good Handling Practices (GAP/GHP) certification program. DATCP's Fruit & Vegetable Inspection Unit is authorized by USDA Agricultural Marketing Service (AMS) to certify farms and facilities under the GAP/GHP program. The central component to the certification process is an on-site audit. This grant provided funds to make these audits (and therefore, certification) financially accessible to more producers and processors, thereby creating new market opportunities for Wisconsin producers. Many large chain stores require food safety certification at the farm level.

The GAP/GHP requirements are governed by AMS. AMS establishes the standards, trains and certifies the state inspectors who conduct the field audits, and issues the GAP/GHP certificates to the growers. USDA also mandates that the price of the audit is $92.00 per hour plus an overhead fee of $50.00. Under this grant agreement, applicants (growers) paid $23.00 per hour (25%) and the grant covered the remaining $69.00 per hour (75%).

In addition, a portion of this grant was originally budgeted to help defray the cost of having Fruit & Vegetable Inspection Unit Auditors provide free workshops and training seminars for growers, and for time spent on continuing education to maintain auditor credentials. The free seminars were typically organized by trade organizations for their members or by processing facilities for their suppliers. They provided an opportunity for growers to learn about the GAP/GHP requirements before requesting the audit and, therefore, more efficiently obtain certification. In addition, auditors are required to complete minimum continuing education coursework on an annual basis to maintain their license.

However, only a partial hour of employee time was included in the fund reimbursement requests because we experienced greater demand for audits than anticipated. All but $13.67 of the $2,800 budgeted for salary & fringe was diverted to reimbursing growers' GAP/GHP audits.

B. The Fruit & Vegetable Inspection Unit received similar grants in previous fiscal years. The work done under this project was a continuation of previous projects.

II. Project Approach

The Fruit & Vegetable Inspection Unit conducted a total of 82 GAP/GHP audits under this grant program. Of these, 56 were "Standard" GAP/GHP audits and 26 were Harmonized GAP. Many of these audits would not have been possible without this grant. Most businesses audited were growers, but there were also some packing & distribution facilities.

The Fruit & Vegetable Inspection Unit offered a total of eight free workshops, seminars or training classes for growers. These eight sessions represented a total of 64 hours by the Fruit &

Vegetable Inspection Unit's Auditors. These workshops were typically arranged by grower trade organizations or by firms that buy the growers' products. These workshops are an excellent opportunity for growers to learn what will be expected should they continue to seek GAP/GHP certification. Although it was in the original grant proposal for the grant to cover $2,800 of the Fruit and Vegetable Inspection Unit's cost of providing these workshops, only a partial hour of time (or $13.67) was submitted for reimbursement. The rest of the grant funds were diverted to covering the cost of GAP/GHP audits for growers.

III. Goals and Outcomes Achieved

A The overall goal of this project was to have more growers obtain GAP/GHP certification. Activities conducted by the Fruit & Vegetable Inspection Unit to achieve this goal include: conducting audits at reduced cost to growers (in other words, defer a portion of the audit expense from the grower to the grant); providing free workshops and training sessions to make sure that audit applicants understand before the audit what will be expected of them; and ensuring that the unit has well-trained, qualified auditors available to conduct the audits and workshops.

B. The unit billed a total of 450.5 hours for 82 audits under this grant. Although this number is considerably lower than the 125 audits that were conducted under the FY12 grant, the total funds available went from $40,000 under the FY12 grant to $30,000 under the FY13 grant. The Fruit & Vegetable Inspection Unit performed as many audits as possible given the funds that were available. There were an additional 55 audits that could have been put into the FY13 grant had there been sufficient funds. Instead, those audits were included on the FY14 grant (the two grant periods overlap). The 82 audits conducted under the FY13 grant is an increase over the 75 that were conducted during the FY11 grant period, 76 during the FY10 grant period, and 55 during the FY09 grant period.

The unit's two auditors spent a total of 64 hours offering workshops and training sessions to growers and other interested parties. This is very comparable to the 65.5 hours that were spent during the FY12 grant period.

IV. Beneficiaries

The direct beneficiaries of this program are the growers who were able to use the cost share grant to help cover the cost of their GAP/GHP audits. Pursuant to AMS standards, the Fruit & Vegetable Inspection Unit must charge $92 per hour for audit services. However, thanks to this grant, the unit was able to charge the growers only 25% of this fee, and then charge the remainder to the grant. This obviously results in a large cost reduction for the growers. The schedule below lists all GAP/GHP audits conducted under the FY13 grant.

standard GAP/GHP						
Audit start date	**Invoice Number**	**Customer Name**	**Hours @ $92.00 per hour**	**Entire Expense**	**Grant portion (75% of total, but limited to $500)**	**Customer Portion** (25% of total, plus any amount above limit)
10/1/2014	15-121-5915	Robert H. Heath Farms Inc.	3.0	276.00	**207.00**	69.00
9/25/2014	15-121-5912	Dean Kincaid Inc.	6.0	552.00	**414.00**	138.00
9/25/2015	15-121-5911	Mike Ben Ben Inc.	6.0	552.00	**414.00**	138.00
9/15/2014	15-121-5909	Amazing Grace Family Farm	6.0	552.00	**414.00**	138.00
9/9/2014	15-121-5908	H and J Williams Farms Inc.	4.0	368.00	**276.00**	92.00
9/23/2014	15-121-5907	Paul Miller Farms Inc.	3.0	276.00	**207.00**	69.00
9/18/2014	15-121-5906	Mocadlo Farms	3.0	276.00	**207.00**	69.00
8/27/2014	15-121-5905	Wysocki Produce Farm, Inc.	7.0	644.00	**483.00**	161.00
9/3/2014	15-121-5904	Wild Seed Farms, Inc.	5.5	506.00	**379.50**	126.50
10/3/2014	15-121-5903	B & D / Wisconsin Central Farms	4.0	368.00	**276.00**	92.00
7/31/2014	15-121-5902	Cedar River Potato Company	5.0	460.00	**345.00**	115.00
7/31/2014	15-121-5901	J. W. Jacobs Farm	5.0	460.00	**345.00**	115.00
8/29/2014	15-121-5894	Hetzel Farms, Inc.	3.0	276.00	**207.00**	69.00
8/29/2014	15-121-5895	Oak Grove Farms, Inc.	3.0	276.00	**207.00**	69.00
9/30/2014	15-121-5896	Sunny Grove Farm	3.0	276.00	**207.00**	69.00
9/26/2014	15-121-5891	Firkus Farms LLC	4.0	368.00	**276.00**	92.00
9/10/2014	15-121-5893	Ted Baginski & Sons, Inc.	5.0	460.00	**345.00**	115.00
8/25/2014	15-121-5890	Weekly Farms	5.0	460.00	**345.00**	115.00
9/9/2014	15-121-5918	Bartsch Farms	4.0	368.00	**276.00**	92.00
10/1/2014	15-121-5926	Igl Farms LLC	4.0	368.00	**276.00**	92.00
9/10/2014	15-121-5928	Hartman Farms, Inc.	7.0	644.00	**483.00**	161.00
9/3/2014	15-121-5933	Helbach Farms LLC	3.0	276.00	**207.00**	69.00
9/5/2014	15-121-5934	Coloma Farms, Inc.	5.0	460.00	**345.00**	115.00
10/15/2014	15-121-5935	Harvest Moon Farms LLC	6.0	552.00	**414.00**	138.00
8/26/2014	15-121-5865	Growing Power Inc.	6.0	552.00	**-**	552.00
9/5/2014	15-121-5867	Patoka Farms LLC	3.0	276.00	**207.00**	69.00
7/31/2014	15-121-5918	Turners Fresh Market	4.5	414.00	**-**	414.00
8/25/2014	15-121-5864	Highland Valley Farm Inc.	9.0	828.00	**500.00**	328.00
8/22/2014	15-121-5869	Green Produce	4.0	368.00	**276.00**	92.00
10/7/2014	15-121-5922	Heck's Market	6.0	552.00	**414.00**	138.00
10/3/2014	15-121-5923	Paramount Farms, Inc.	5.0	460.00	**345.00**	115.00
9/24/2014	15-121-5924	Gagas Farms, Inc.	3.0	276.00	**207.00**	69.00
8/29/2014	15-121-5925	Wagner Farms of Adams County, Inc.	6.0	552.00	**414.00**	138.00
9/10/2014	15-121-5927	Nicolet Farms, Inc.	6.0	552.00	**414.00**	138.00
11/10/2014	15-121-5939	Flyte Family Farms LLC	4.0	368.00	**276.00**	92.00
9/19/2014	15-121-5942	Cala Farm "Origenes", LLC	6.0	552.00	**414.00**	138.00
11/16/2014	15-121-5943	Liberty Packing Inc.	3.0	276.00	**207.00**	69.00
12/5/2014	15-121-5944	McCain Foods USA Inc.	4.0	368.00	**276.00**	92.00

12/19/2014	15-121-5945	Harvest Moon Farms LLC	6.0	552.00	**414.00**	138.00
6/4/2015	15-121-5961	Wisconsin Land Co-op LLC / Spears-R-Us	4.0	368.00	**276.00**	92.00
7/22/2015	16-121-5964	Gitzlaff Farms, Inc.	8.0	736.00	**500.00**	236.00
7/27/2015	16-121-5968	Werys Blossom Creek	4.0	368.00	**276.00**	92.00
7/23/2015	16-121-5967	Jonathan Allgyer	5.0	460.00	**345.00**	115.00
7/23/2015	16-121-5966	Samual King (Whitetail Ridge Farm)	6.0	552.00	**414.00**	138.00
7/29/2015	16-121-5972	Highland Valley Farm Inc.	9.0	828.00	**500.00**	328.00
7/30/2015	16-121-5969	Amazing Grace Family Farm	7.0	644.00	**483.00**	161.00
8/5/2015	16-121-5973	Parisi Family Farm	6.0	552.00	**414.00**	138.00
8/11/2015	16-121-5975	Robert H. Heath Farms Inc.	4.0	368.00	**276.00**	92.00
8/26/2015	16-121-5978	Renaissance Farm	5.5	506.00	**379.50**	126.50
7/22/2015	16-121-5980	Future Farm Food and Fuel LLC	8.0	736.00	**500.00**	236.00
8/18/2015	16-121-5976	Hoekstra's Sweet Corn LLC	6.0	552.00	**414.00**	138.00
9/10/2015	16-121-5985	Bula-Gieringer Farms II, LLC	6.0	552.00	**414.00**	138.00
8/19/2015	16-121-5986	Kizewski Farms	4.0	368.00	**276.00**	92.00
9/11/2015	16-121-5988	Jandt Farms	7.0	644.00	**483.00**	161.00
9/9/2015	16-121-5989	Wild Seed Farms Inc.	4.0	368.00	**276.00**	92.00
9/3/2015	16-121-5990	Patoka Farms LLC	3.0	276.00	**207.00**	69.00
Total -- Standard Audit			**281.5**	**$ 25,898.00**	**$ 18,353.00**	**$ 7,545.00**

Harmonized GAP						
Audit start date	**Invoice Number**	**Customer Name**	**Hours @ $92.00 per hour**	**Entire Expense**	**Grant portion (75% of total, but limited to $800)**	**Customer Portion** (25% of total, plus any amount above limit)
9/29/2014	15-121-5940	Mammoth Produce	7.0	644.00	**483.00**	161.00
9/17/2014	15-121-5919	Gumz Muck Farms, LLC	9.0	828.00	**621.00**	207.00
9/15/2014	15-121-5920	Jack's Pride Farms, Inc.	7.0	644.00	**483.00**	161.00
9/26/2014	15-121-5929	Myron Soik & Sons, Inc.	4.0	368.00	**276.00**	92.00
10/6/2014	15-121-5930	Fenske Farms, Inc.	4.0	368.00	**276.00**	92.00
10/7/2014	15-121-5931	James Spychalla Farms, Inc.	5.0	460.00	**345.00**	115.00
9/10/2014	15-121-5936	Schroeder Bros. Farms, Inc.	8.0	736.00	**552.00**	184.00
10/1/2014	15-121-5941	Mike Wolter Riverside Farms, Inc.	6.0	552.00	**414.00**	138.00
5/20/2015	15-121-5960	Nuto Farms Inc.	8.0	736.00	**552.00**	184.00
7/16/2015	16-121-5970	Trembling Prairie Farms, Inc.	7.0	644.00	**483.00**	161.00
7/29/2015	16-121-5971	Prairie Star Ranch, Inc.	6.0	552.00	**414.00**	138.00
8/20/2015	16-121-5977	Oakwood Fruit Farm	7.0	644.00	**483.00**	161.00
8/25/2015	16-121-5979	Alsum Farms, Inc.	8.0	736.00	**552.00**	184.00

9/1/2015	16-121-5981	Sunrise Orchards	8.0	736.00	**552.00**	184.00
9/17/2015	16-121-5993	Yeska Brothers Farms	4.0	368.00	**276.00**	92.00
9/3/2015	16-121-5994	Plover River Farms Alliance, Inc.	5.0	460.00	**345.00**	115.00
9/8/2015	16-121-5984	Ferguson's Orchards	12.0	1,104.00	**800.00**	304.00
9/11/2015	16-121-5991	Fletcher Farms Inc.	6.0	552.00	**414.00**	138.00
9/15/2015	16-121-5992	Worzella & Sons, Inc.	4.0	368.00	**276.00**	92.00
9/16/2015	16-121-5995	Trembling Prairie Farms, Inc.	4.0	368.00	**276.00**	92.00
9/10/2015	16-121-6001	Schroeder Bros. Farms Inc.	7.0	644.00	**483.00**	161.00
9/30/2015	16-121-6018	Coloma Farms, Inc.	6.0	552.00	**414.00**	138.00
10/2/2015	16-121-6023	Paramount Farms Inc.	6.0	552.00	**414.00**	138.00
9/23/2015	16-121-6008	Gumz Muck Farms, LLC	8.0	736.00	**552.00**	184.00
8/20/2015	16-121-6034	Specialty Potatoes and Produce LLC	6.0	552.00	**414.00**	138.00
9/14/2015	16-121-6025	Flyte Family Farms, LLC	7.0	644.00	**483.00**	161.00
Total -- Harmonized GAP Audit			**169.0**	**$ 15,548.00**	**$ 11,633.00**	**$ 3,915.00**

V. Lessons Learned

We have implemented similar grant projects in 2011 and 2012. This was the first year we used the entire grant award and spent more on the cost share portion of the grant than originally planned. It was nice to see the increase in participation in the program. Our efforts to get the word out about the program have paid off.

VI. Additional Information

None

VII. Contact Info

Jeremy McPherson
Director of Trade Practices
Wisconsin Department of Agriculture, Trade, and Consumer Protection
P.O. Box 8911
Madison, WI 53718
608-224-4922
jeremy.mcpherson@wi.gov

16) Safe food handling skills for Hmong fresh produce (FY13-016)

Report Date: June 8, 2015

I. Project Summary

For the past 5 years, the Wisconsin Department of Agriculture, Trade & Consumer Protection (DATCP) has been working on an outreach and assistance project to reach underserved specialty crop farmers. The majority of them have been fresh market growers; the rest grow ginseng. Our underserved farmers have not typically participated in educational workshops from mainstream sources. Through workshop evaluations, surveys, and individual conversations with underserved farmers, they expressed the following desires:

- to improve their farming practices
- programming that is culturally relevant and in their native language
- to learn proper methods of using pesticides and herbicides
- to integrate more organic practices into their farming methods
- to increase their production
- to improve their sales
- hands-on and farmer-to-farmer learning
- information on safe food handling

Therefore, this project focused on developing and delivering workshops on safe food handling procedures, specifically for these underserved growers. They have reported that customers are asking them about their food safety practices and they want to be able to serve their customers better in this regard. So improving producer knowledge and skills in these areas will enhance their markets. The workshops also lay the groundwork for Good Agricultural Practices (GAPs) certification. Although only a subset of Hmong fresh market producers are likely to move their business in the direction of GAP certification, some do wish to reach larger markets and GAPs will become an important tool in this regard.

B. This project built on our previous FY 10 and 11 Specialty Crop Block Grant Workshops for Underserved Fresh Market Growers and a FY 13 USDA Risk Management grant to work with Hmong growers on safe food handling and farm financial literacy skills. We will be using food safety training materials and approaches for Hmong growers that have been used and improved upon from these previous grant projects. The project also builds on what we've learned as presenters through prior outreach.

Our project focused on safe food handling techniques and an introduction to GAP records. We used materials developed specifically for Hmong farmers by Michele Schermann from the University of Minnesota to teach safe food handling methods. The workshop and materials have been tested with numerous Hmong farmer groups in Minnesota and in Wisconsin. The project director, Jack Chang, has completed the Cornell University Online Produce Safety Course, *Implementing GAPs: a Key to Produce Safety*. He was able to teach aspects of this class to Hmong fresh market producers in their own language as well as the basic sanitation and other information from Schermann's workshops.

II. Project Approach

During the winter season 2013-14, we were able to conduct three safe food handling skills workshops for Hmong fresh produce growers in Wisconsin. The first workshop was held in Milwaukee on 2/8/2014. We had a total of 20 Hmong fresh produce growers attended this workshop. Evaluations from the workshop showed that all participants felt they had learned enough to feel confident about using the information presented. Most of them also stated that they wanted to learn about fertilizers and pesticide application. The second workshop was held in Madison on 2/22/2014. We had a total of 5 Hmong fresh produce growers attend. Evaluations from this workshop showed that all participants felt they had learned enough to feel confident about using the information presented. They also stated that they wanted to learn about pesticide application, business operation and tractor safety. The third workshop was held in Sheboygan on 3/15/2014. We had a total of 13 Hmong fresh produce growers attend. Evaluations from this workshop showed that all participants felt they had learned enough to feel confident about using the information presented. They also gave us some feedbacks that they wanted to learn about pesticide application, soil amendments, and seedling transplanting.

Early spring 2014, we recruited and provided trainings to 6 Hmong fresh produce growers on 4/10 & 11, 2014 in Wisconsin Dells. All 6 Hmong fresh produce growers completed the training and signed a volunteer agreement with DATCP. These new Hmong mentors were from the desirable locations (Madison, Milwaukee and Wausau) as we stated on our grant proposal.

Early summer, we hosted an on-site safe food handling training on 6/22/2014 at a farm in Hatley near Wausau, Wisconsin. We invited a representative from Farm Logix, a food distribution center in Chicago, Illinois to talk about their operation and how they do business with small scale fresh produce growers. We had a total of 13 Hmong fresh produce growers at the training site. They enjoyed the farm tour and the post-harvesting demonstration. Evaluations from this training showed that all participants felt they had learned enough to feel confident about using the information presented. They wanted to learn more on food safety and create their own safe food handling manual for their farm operations. A few Hmong fresh produce growers stated that they would prepare to be ready to sell their fresh produce to big buyers for next crop season.

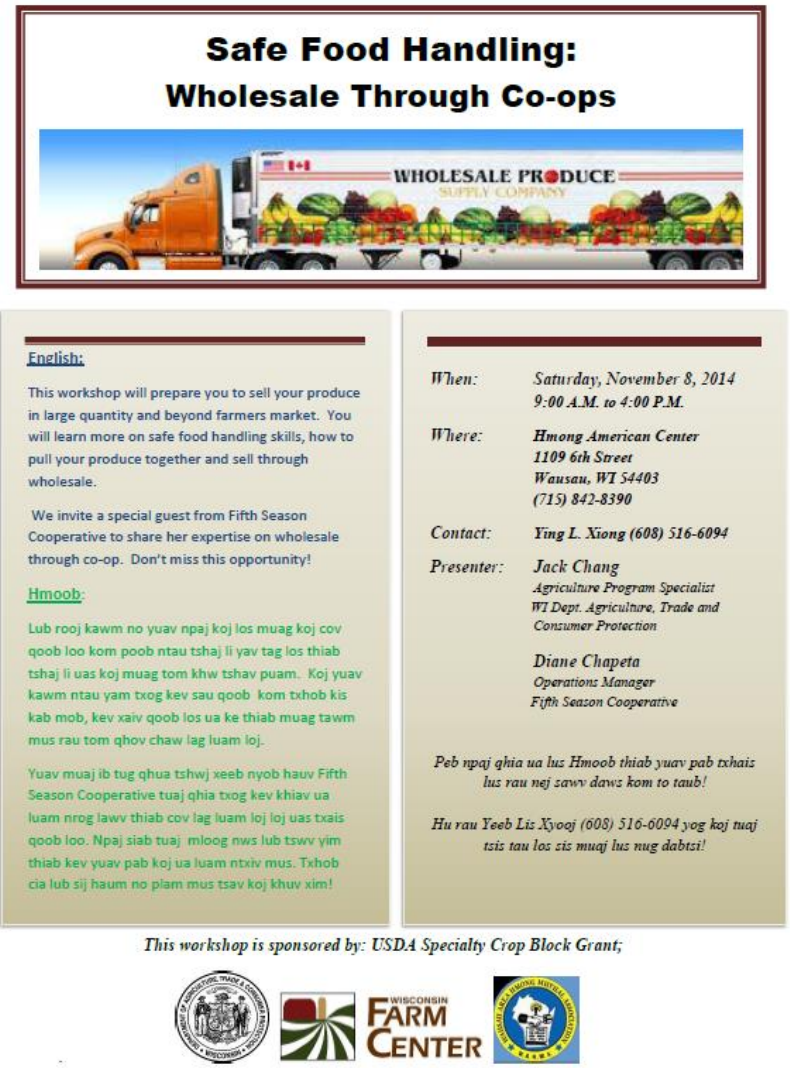
During the fall 2014 season, we were able to conduct four more safe food handling skills workshops for Hmong fresh produce growers in Wisconsin. The first workshop was held in Wausau on 11/8/2014. We had a total of 17 Hmong fresh produce growers attended this workshop. The second workshop was held in Stevens Point on 11/9/2014. We had a total of 10 Hmong fresh produce growers attended this one. The third workshop was held in La Crosse on 11/15/2014. We had a total of 3 Hmong fresh produce growers attended this one. The fourth workshop was held in Eau Claire on 11/22/2014. We had a total of 20 Hmong fresh produce growers attended this one. Evaluations from this workshop showed that all participants felt they had learned enough to feel confident about using the information presented. Topics for future training requested in evaluations from all four workshops included fertilizer, insecticide, and pesticide application, marketing and selling through co-ops and/or wholesale.

III. Goals and Outcomes Achieved

A. We worked with Hmong community centers and churches to secure the dates and sites for workshops. We also worked with other agencies such as UW Extensions, Fifth Season Co-op, Farm Logix and other Divisions within the Wisconsin Department of Agriculture, Trade and Consumer Protection on guest speakers and presentations. We created workshop flyers and promoted through network, US mail, Hmong radio programs, word of mouth and telephone calls. See Appendix A for an example of a flyer that was mailed.

An evaluation was given after each workshop. We reviewed the evaluations for future improvements/topics. We followed up with Hmong growers who had questions and/or wanted one-to-one assistance. At the end of the project, we implemented a post evaluation by telephone to get the highest rate of and most accurate responses. Our staff invested lots of time and commitment to conduct and complete this post evaluation. We were not able to contact all the workshop participants due to a busy crop season for growers and changes of contact information. However, we got a good picture of how our workshops impacted their farm operations and decision making after talking to so many of them. See Exhibit B for the result of the post evaluation.

Appendix A:



Safe Food Handling:
Wholesale Through Co-ops

WHOLESALE PRODUCE SUPPLY COMPANY

English:

This workshop will prepare you to sell your produce in large quantity and beyond farmers market. You will learn more on safe food handling skills, how to pull your produce together and sell through wholesale.

We invite a special guest from Fifth Season Cooperative to share her expertise on wholesale through co-op. Don't miss this opportunity!

Hmoob:

Lub rooj kawm no yuav npaj koj los muag koj cov qoob loo kom poob ntau tshaj li yav tag los thiab tshaj li uas koj muag tom khw tshav puam. Koj yuav kawm ntau yam txog kev sau qoob kom txhob kis kab mob, kev xaiv qoob los ua ke thiab muag tawm mus rau tom qhov chaw lag luam loj.

Yuav muaj ib tug qhua tshwj xeeb nyob hauv Fifth Season Cooperative tuaj qhia txog kev khiav ua luam nrog lawv thiab cov lag luam loj loj uas txais qoob loo. Npaj siab tuaj mloog nws lub tswv yim thiab kev yuav pab koj ua luam ntxiv mus. Txhob cia lub sij haum no plam mus tsav koj khuv xim!

When: Saturday, November 8, 2014
9:00 A.M. to 4:00 P.M.

Where: Hmong American Center
1109 6th Street
Wausau, WI 54403
(715) 842-8390

Contact: Ying L. Xiong (608) 516-6094

Presenter: Jack Chang
Agriculture Program Specialist
WI Dept. Agriculture, Trade and Consumer Protection

Diane Chapeta
Operations Manager
Fifth Season Cooperative

Peb npaj qhia ua lus Hmoob thiab yuav pab txhais lus rau nej saws daws kom to taub!

Hu rau Yeeb Lis Xyooj (608) 516-6094 yog koj tuaj tsis tau los sis muaj lus nug dabtsi!

This workshop is sponsored by: USDA Specialty Crop Block Grant;

WISCONSIN FARM CENTER

Appendix B:

SCBG FY13: Safe Food Handling Skills for Hmong Growers Post-Evaluation Summary

41 Hmong growers participated the Post-Evaluation

By completing this evaluation, will help us serve you better.

1. Are you already using some safe food handling techniques you learned from the workshop?

☐ Yes, which ones? **100% (41 Hmong growers)**

- Washing my hands properly.
- Washing my hands properly before touching my fresh produce.
- Building a hand washing station.
- Cleaning my containers and harvested equipment before and after used.
- Worker good health and hygiene.
- Washing hands properly.
- Worker hygiene.
- Washing hands properly.
- Personal hygiene.
- Worker hygiene—washing hands and wearing proper clothing.
- Hand washing technique.
- Hand washing technique and worker hygiene.
- Managing fertilizer—using chicken manure.
- Separating farm clothes from regular clothes.
- Proper hand washing technique.
- Worker good health and hygiene—washing hands and wearing clothes properly.
- The proper hand washing technique.
- Washing hands technique.
- Washing hands technique.
- Hand washing technique.
- Worker hygiene—especially washing hands technique.
- Hand washing technique and wearing proper clothes for the work.
- Washing hands technique.
- Washing hands and wearing clothes properly.
- Using clean boxes or containers for my fresh produce.
- Washing hands technique
- Washing hands and wearing gloves.
- Worker hygiene—especially washing hand before touching fresh produce.
- Washing hands technique.
- Worker hygiene—washing hands, wearing proper clothing and no jewelry.
- Washing hands technique.
- Washing hands technique.
- Washing hands technique.
- Washing hands technique.
- Proper hand washing technique.
- Washing hands and dressing properly.

- Hand washing technique.
- 3-stage of cleaning vegetables in post harvesting.
- Putting vegetables in clean containers and store above ground.
- Keeping containers and other harvested equipment clean.
- Testing water for post harvesting.
- Cleaning containers and harvested equipment.
- Storing vegetables in clean containers and put above ground.
- Storing fresh produce above ground.
- Using clean water for cleaning and post harvesting.
- Cleaning my containers and storing my fresh produce above ground.
- Putting my vegetables in a clean container and store above ground.
- Cleaning containers and harvested equipment.
- Cleaning my harvested equipment and cargo van.
- Cleaning my cargo van after using for other things.
- Storing fresh produce above ground and under shade.
- Storing fresh produce above ground in clean containers.
- Hand washing technique.
- 3-stage of washing and cleaning our vegetables.
- Worker good health and hygiene—when I get sick, I don't handle fresh vegetables. I do weeding and other things instead.

☐ No

2. Have you decided to implement additional safe food handling techniques (e.g. cleaning containers, harvested knives, store fresh produce above ground level…) in your business?

☐ Yes, which ones? **100% (41 Hmong growers)**

- Worker good health and hygiene.
- Cleaning and sanitizing containers and farm equipment.
- Cleaning my containers and harvested knives after using and store them properly.
- Will build a cooler for my fresh crops.
- Worker good health and hygiene.
- Cleaning and sanitizing containers and harvested equipment.
- Cleaning containers and harvested knives.
- Storing fresh produce above ground level.
- Cleaning containers and store fresh produce above ground.
- Cleaning containers and harvested knives properly.
- Cleaning containers and farm equipment.
- Storing vegetables above ground.
- Cleaning containers for fresh produce and other farm equipment.
- Cleaning my containers, harvested knives and vehicle.
- Cleaning containers, using clean water for post harvesting and proper hand washing.
- Cleaning containers and harvested equipment.
- Cleaning harvested equipment and store them properly.
- Cleaning containers and other farm equipment.
- Testing water for post harvesting.

- I taught my family members to wash hand properly and clean all the containers and harvested equipment thoroughly each day.
- I built a hand washing station at my farm.
- Cleaning and sanitizing containers, harvested equipment and vehicle.
- I organize and clean my containers, harvested equipment and vehicle.
- Cleaning vehicle and storing fresh vegetables above ground.
- Using clean water for post harvesting.
- Storing fresh vegetables above ground level.
- I built a portable hand washing station for my farm after attending the workshop.
- Storing our vegetables in clean containers and stock above ground.
- Storing fresh vegetables in clean or new containers and stock above ground.

☐ No, why not? _____

3. Have you begun to use good agricultural practices (GAPs) record keeping for your farm operation?

☐ Yes, when? **51% (21/41 Hmong growers)**

- Mapping and crop planning for 2016.
- Keeping track on my fresh produce at farmers market.
- I started using the crop planning for my crops in 2015.
- Keeping a log for cleaning my containers and harvested equipment.
- Keeping record of crops planting this year for crop planning next year
- Practice using the crop planning and produce grading for next year.
- Keeping record of crops planting for crops planning next year.
- Keeping a record of cleaning my farm equipment.
- I keep a record of cleaning my containers, equipment and vehicle.
- I have been using the cleaning containers and harvested equipment procedure and recorded in a log.
- Keeping a log on water testing for my fresh produce.
- Creating a cleaning procedure and keeping log on the cleaning.
- Keeping a log for testing the water.
- Keeping a log for water testing.
- Creating a log to record harvested equipment cleaning and another log for water testing.
- Keeping logs for harvested equipment cleaning.
- I evaluate my crops and prepare for the big market in the near future.
- Mapping my farm and keeping record of the crops I planted.
- I keep a record of testing my well water.
- I schedule time to clean my containers, harvested equipment and vehicle and record in a log.
- Mapping and naming each field for crops planting record.

☐ No, why not? **49% (20/41 Hmong growers)**

- I am busy.
- I don't have time.
- I am busy.

- I am not ready yet.
- I use my past experiences and memory.
- I don't have time.
- Don't have time.
- I will think about it in the future.
- I'm too busy.
- Not yet, but I will think about it.
- I don't have time for the record keeping.
- I don't have time!
- I'm not ready yet.
- Not yet. I will ask my children to create a cleaning log.
- Not yet. I will think about it.
- I don't have time!
- I don't have time.
- I am too busy.
- I'm too busy right now. I will consider it next time.
- I don't have time for the record keeping.

4. What are some other topics you like to discuss or be learned/trained?

- I want to know more about how to start a farm organization.
- I want to learn more about wholesaling.
- I want to get my GAPs certification and sell my fresh produce to big buyers.
- I will learn anything that you bring to me.
- I like to know more about Good Agriculture Practices Certification and selling to big buyers.
- Everything.
- I want to know more about grants and other resources to help beginning farmers.
- Selling to big corporations.
- I am a new farmer. There are lots to learn to become a good farmer. I will learn anything that you offer.
- How to get GAPs Certification and sell direct to big corporations.
- Soil sample testing because my soils are depleting.
- I will attend any future workshop in my area.
- Field day training—like to have hand on experience.
- Soil sample testing.
- Everything that is important in farming.
- I plan to build a walk-in cooler. A space is already created and an AC unit is bought.
- Waiting 2 weeks (after applying pesticide application) before harvesting.
- I want to know other market options.
- Everything.
- How to build an affordable cooler.
- I want to know/learn how to germinate seeds and seedlings.
- If you have any new updates/topics, bring to us.
- Soil amendments.
- Fertilizers and pesticide applications.
- How to sell directly to big buyers.
- I need help with putting a cooler together.
- How to market to big buyers.
- Forming a wholesale or organization.

- Connecting to big buyers.
- Pesticide application.
- I will learn anything that you bring to us.
- Insects control.
- Connecting to co-ops and/or wholesale.
- I want to learn more on selling through co-ops and wholesale.
- Selling through co-ops or wholesale.
- Tractor safety and chemical safety.
- Farm business plan.
- I would like to learn more about fertilizers and pesticide application.
- How to select and plant flowers.
- I want to learn fungicide, pesticide and fertilizer application next time.
- After attending the safe food handling workshop, we decided to buy a machine to wash and clean our root vegetables such as carrots, beets, etc…
- Next time teach us the fungicide and pesticide application.
- I want to learn about fertilizers and how to select the right one for my garden.
- How to reach chemical labeling and farming loans.

B. Our goals were to offer 8 workshops on safe food handling and Good Agriculture Practices (GAPs) to underserved producers, targeting attendance of 80 farmers (primarily Hmong). In addition, 5 new Hmong mentors would be recruited and complete a 2 day training.

Expected Measurable Outcomes:

- 80 Hmong growers attend Food Safety workshops
- 90% (72) of these will understand the value of practicing safe food handling techniques as a risk management tool.
- 90% (72) of these will understand how to properly wash their hands.
- 75% (60) will decide to implement additional safe food handling techniques in their business.
- 5% (4) will decide to begin GAP record keeping.
- 5 Hmong mentors are trained.

As results, we offered 9 workshops on safe food handling and Good Agriculture Practices (GAPs) in Western, Central, South Central and East Central Wisconsin areas and reached to 107 Hmong fresh produce growers. We also recruited 6 new Hmong mentors and completed the 2 day training on April 10 and 11, 2014.

Actual Measurable Outcomes:

- 107 Hmong growers attended Food Safety workshops
- 100% (41) of the 41 Hmong growers who participated the post evaluation understood the value of practicing safe food handling techniques as a risk management tool.
- 100% (41) of the 41 Hmong growers who participated the post evaluation understood how to properly wash their hands.
- 100% (41) of the 41 Hmong growers who participated the post evaluation decided to implement additional safe food handling techniques in their business.
- 51% (21) of the 41 Hmong growers who participated the post evaluation decided to begin GAP record keeping.
- 6 Hmong mentors were trained.

IV. Beneficiaries

Hmong growers who attended these safe food handling and Good Agriculture Practices (GAPs) understood the importance of worker health and hygiene. They indicated that they knew how to washing hands properly before touching fresh produce. They washed and cleaned their containers and harvesting equipment. They put their fresh produce in clean containers and store above ground level. They were able to build their own hand washing stations and affordable coolers. Many of them started to keeping food safety records and began preparing for selling through cooperatives and/or wholesale.

V. Lessons Learned

Conducting the post evaluation during the crop season was a challenge. Our staff had hard time connecting with the Hmong growers who attended our workshops to complete the post evaluation. Everyone was busy at the farm, farmers market, and other commitments so it took us several months to complete this post evaluation. For future evaluations, we will conduct during the off season.

VI. Additional Information

None

VII. Contact Info

Kathy Schmitt
Farm Center
Wisconsin Department of Agriculture, Trade and Consumer Protection
P.O. Box 8911
Madison, WI 53708
608-224-5048
Kathy.schmitt@wi.gov

17) Salad bars in schools go local (FY13-017)

Report Date: July 21, 2015

I. Project Summary

In 2012, REAP Food Group worked with Madison Metropolitan School District to pilot the use of salad bars in schools. By fall, 2013 the district had obtained salad bars for 18 schools and began to implement the bars as a means for fruit and vegetable service. In addition to contributing to increased produce consumption by students, salad bars provide the opportunity for delivering and showcasing a variety of local specialty crop products in school lunches. With this project, REAP sought to assist MMSD in overcoming sourcing and logistical supply chain and purchasing barriers to procurement of locally-grown produce for the salad bars.

The timeliness of this effort was highlighted by the fact that MMSD was making a big change in its lunch service by transitioning to salad bars. This altered food service operations including school menus, kitchen prep protocol and produce purchasing. Given these changes, it seemed an opportune time to make changes in sourcing protocols as well to include more local produce. Furthermore, bars offered a new and exciting way to serve and promote the produce to students.

B. This project built off of SCBG FY09 – Processing Fruits and Vegetables for Wisconsin Schools. That grant allowed REAP to expand our Farm to School Snack Program and expertise in the areas of sourcing locally for schools and processing local products. We were able to use knowledge gained through expanding the Snack Program to make recommendations for local sourcing for salad bars and school lunch.

II. Project Approach

Increasing local produce served in MMSD schools:

Fall Farm Days

Fall Farm Days is MMSD's celebration of October, National Farm to School Month. REAP and MMSD worked together on sourcing and promoting local items for school lunch service in the month of October.

***2013*:** Fall Farm Days 2013 included the service of four local items on MMSD salad bars: beauty heart radish slices, kohlrabi sticks, coleslaw (local cabbage) and potato salad (local potatoes). In addition, MMSD purchased the WI Harvest Medley Blend to serve at all schools. October 2013 marked the first time that every school in MMSD served local produce. In total, over 2,200 pounds of local produce was served in October for school lunch - over $2,400 spent by MMSD on the effort.

2014: One highlight of Fall Farm Days 2014 was an elementary "All Wisconsin" menu, which featured local apples, edamame, and sweet potatoes, in addition to non-produce local items. Throughout the month, middle schools and high schools served local root vegetable blends as part of their hot lunch. Total spending by MMSD on Fall Farm Days local produce totaled more

than $5,000 – greater than double the amount spent the previous year. For the second year in a row, all MMSD schools received local produce during October.
***Conclusion*:** Fall Farm Days is a successful program to promote local items under the umbrella of National Farm to School Month. It is beneficial to tap into other national and regional coordinated efforts – both promotion and procurement. It is important, however, to continue to work to bring the success of Fall Farm Days to other months as well with the goal of incorporating Farm to School into regular meal service.

Summer Food Service Program
2014: This was the first time local produce has ever been incorporated into the district's Summer Food Service Program, which provides free meals to children throughout the summer months. MMSD purchased five items from REAP for this program (snap peas, summer squash, radishes, kohlrabi and green beans), all sourced by REAP directly from small local farms within 100 miles of Madison. REAP sourced, processed and provided MMSD all of the fresh local produce, utilizing the FEED Kitchen Facility in Madison for the processing. Each week, 1-3 local items were served as the fresh vegetable portion of the summer meals. As reported in our Interim Report, an estimated 50,000 servings of local produce went to students, over 4,500 pounds and over $11,000 spent. REAP assisted MMSD with all aspects of this program – from procurement, to educational menu content and cafeteria promotional events.
Conclusion: This summer procurement was a huge success – over $11,000 staying in our local communities, in addition to the health and educational benefits. However, the amount of effort on REAP's part was large – specifically the individual procurement work with farmers and the processing of the vegetables at the FEED Kitchen. For 2015, we have done significant planning to have a regional processing entity take over this role of supplying local summer produce to MMSD. As of this report the summer is still in progress, but there has already been three additional local items served (cherry tomatoes, tomatoes, cucumbers) compared to last year and we expect local produce to total over 6,000 pounds by the end of the summer. We have continued providing educational menu content to MMSD and summer meal site support and educational engagement.

Carrot and Kohlrabi Pilot 2015
REAP coordinated pilot service of locally-grown carrots and kohlrabi in February and March, 2015. This project had many moving pieces and partners involved. REAP identified a regional processing entity – the Wisconsin Innovation Kitchen – interested in sourcing local produce to MMSD, assisted them in becoming a registered vendor, and helped them through the logistics of school procurement. Due to the MMSD's GAP certification requirement for produce served as part of the National School Lunch Program, it was necessary for REAP to locate GAP certified farms (assisting one of the farms in obtaining GAP specifically for MMSD) and connect them to the WI Innovation Kitchen. The pilot project resulted in 1,300 pounds of carrots and 850 pounds of kohlrabi served on all MMSD salad bars and at all elementary schools. MMSD spent over $3,000 on local produce for this pilot.
Conclusion: While the legwork behind this effort was immense, the project was less about the amount served during the pilot period and more about developing a sustainable pipeline for processed local produce from farms through the WI Innovation Kitchen to MMSD. Indeed, it was a trial run for what will hopefully be a long-term successful Farm to School partnership. Both MMSD and WI Innovation Kitchen came away from the pilot feeling very positive and

eager to work together on more items. Indeed, REAP coached WI Innovation Kitchen in supplying MMSD with produce for the 2015 Summer Food Service Program, which is currently ongoing. Six different local products have been continuously procurement for MMSD over the summer thus far, some of which require fresh cut processing. We remain optimistic about continuing procurement into the academic year.

Increasing the Number of Schools with Salad Bars:
While much of the work for this SCBG has gone into local sourcing supply chain development for Farm to School, REAP has also continued to work hard to get more MMSD schools outfitted with salad bars. When the grant period began, 18 schools had salad bars. Currently, 29 MMSD schools operate salad bars on a daily basis. REAP has actively fundraised for salad bar infrastructure at schools, as well as assisted MMSD with salad bar installation, educational assemblies and promotional materials. Given that salad bars have been shown to positively impact student fruit and vegetable consumption, it remains vital to work to make it possible for salad bars at all 48 MMSD schools. For REAP as a local food system organization, salad bars have the added benefit of providing a great way to serve and highlight local WI produce.

III. Goals and Outcomes Achieved

Project activities included:

- Regular meetings with MMSD Food Service Director and Management team to determine opportunities for inclusion of local produce, identify barriers, and lay plans for Farm to School items in school lunch, including salad bars.
- Meetings with producers, processors and supply chain entities and experts to identify opportunities for local produce sourcing to MMSD. Included assisting farmers with GAP certification and processors with school bidding and purchasing procedures.

  Progress towards goals: Relationships and communication are key to developing a regional supply chain that works for Farm to School. REAP worked to broker relationships between MMSD Food Service and regional suppliers, walking Food Service through differences in local food supply verses conventional channels and assisting suppliers with the intricacies and complexities of school food procurement. The long-term goal is sustained and regular procurement of local produce; these efforts build capacity for this goal.

- Alteration of procurement practices and protocols to better accommodate local produce. This involved close work with the MMSD Food Service Purchasing Manager and included development of both formal and informal bidding documents and processes for F2S products.

  Progress towards goals: both informal and formal bidding documents were developed and used. Formal procurement for the Summer Food Service Program was structured in a way to better accommodate product seasonality, and this procurement was carried out successfully for both summer 2014 and summer 2015. MMSD has been wary of informal procurement, but documents were developed and successfully used for the carrot and kohlrabi pilot. These are concrete steps toward more local purchasing via multiple

purchasing methods, and we look to continue to bring changes to the weekly produce bidding system as well.

- Analysis of quantity, price points, labor and processing metrics to determine the best products for Farm to School. This work included fusing seasonality with school menu timelines, analysis of MMSD's equipment and labor capacity for processing local vegetables at their central kitchen, and review of budget and purchasing records to determine price feasibility and flexibility for Farm to School products.

  Progress towards goals: we were able to identify products that were most feasible and pilot the purchase of them in February and March, 2015. This solidified a potential relationship with farmers and a regional processor that we continue to develop. We also continue to explore the possibility of processing produce at the MMSD kitchen and the development of seasonally-appropriate menu items. This work is ongoing.

- Adding salad bar sites – this work included securing funds for school site salad bar infrastructure (refrigeration, plumbing, etc.) so that salad bars could be launched at new sites. Work also included school site selection, implementation and educational assemblies, staff training, and development of educational and promotional materials for salad bar sites, specifically in regards to the inclusion of local produce.

  Progress towards goals: 29 schools currently (end of academic year 2014-2015) operate salad bars. At the start of the grant period, 18 salad bars were in use. These efforts to make salad bars a reality at MMSD schools continue, as there are 48 schools in the district. Many of the remaining schools require expensive renovations and equipment before they can accommodate salad bars.

B. Goal I: Increase the amount of fruits and vegetables sold by local farmers to the MMSD for use in the salad bars in their school meal program:
-Benchmark from 2012-2013 school year: $500/year
Actual accomplishments: We were able to increase amount spent by MMSD on local produce for school meal service each year of the project.

-2013-2014: $12,500 (increase of $12,000 from previous year)

-2014-2015: over $25,000 (double the previous year). Note that this does not include what we expect to be spent for the 2015 Summer Food Service Program, which we project to be an additional $10,000-$15,000 worth of local produce.

*It is also worth noting that these numbers reflect total local produce purchases, not solely purchase for salad bar use. Over the course of the grant period, it became clear that MMSD often purchases items to serve on salad bars as well as other forms of service. As such, separating out salad bar data would not reflect overall local produce spending.

Goal II: Increase the number of schools within the MMSD serving locally-grown produce as part of the reimbursable meal program
-Benchmark from 2012-2013 school year: 3 elementary schools as part of a pilot program for one week each.

Actual accomplishments: It is exciting to report that local produce was served in school meals at all MMSD schools in October 2013 and October 2014 as part of Fall Farm Days. In addition, the 2015 carrot and kohlrabi pilot brought locally-grown produce to all elementary schools and salad bar schools (45 schools total) over a two-week period. The 2014 Summer Food Service Program brought local produce to 39 sites over an 8-week period. The 2015 Summer program is serving local produce at 43 sites.

Goal III: Create bidding and purchasing protocols for the school meal program that do not exclude WI farmers
-Benchmark from 2012-2013 school year: no bidding or purchasing protocols that are local-farmer friendly.
Actual accomplishments: Developed informal bidding procedures and documents for informal procurement of local produce. Successfully piloted these procedures in Summer 2014 and February 2015. Assisted in the development of formal bid documents for summer local procurement – successful formal procurement of local produce was achieved in June 2015.

Goal IV: Increase the amount of fresh-cut, ready-to-use produce processed by local and regional processors for use in MMSD salad bars.
-Benchmark from 2012-2013 school year: Approximately 400 lbs (used during salad bar pilot, processed by Just Local Foods.)
Actual accomplishments:
-2013-2014 School year and summer: over 2,200 lbs processed by Just Local Foods and WI Harvest Medley for October Fall Farm Days; over 4,500 lbs processed at FEED Kitchens for summer meals.
-2014-2015 School year: 17,000 lbs (processors: 5th Season Coop/Sno Pac, WI Innovation Kitchen, V Marchese, Richland Hills)
-2015 Summer: over 6,000 lbs

Goal V: Present best practices and finding from this project to assist other schools in sourcing locally grown vegetables for use in their salad bars
Actual accomplishments: Presented at 2015 WI Farm to School Summit, provided content, findings and recommendations for WI Farm to School and National Farm to School Network publications and toolkits.

WI producers and local produce vendors: Over the course of the grant period, MMSD will have spent an estimated $50,000 on local produce for the lunch program. These funds went either directly to WI specialty crop growers, or to WI vendors and processors such as WI Innovation Kitchen, 5th Season Cooperative, V Marchese and Richland Hills. Even greater than the $50,000 impact is the system being put in place for continued Farm to School purchases at MMSD.

MMSD students: Over 25,000 students at 48 MMSD schools (and 43 summer food sites including community centers and neighborhood sites) had the opportunity to eat WI-grown produce at lunch. 50% of the MMSD student population qualifies for free or reduced lunch, meaning that the majority of students eating school lunch experience economic disadvantage. Being able to reach these students with fresh local produce is extremely valuable and important,

especially given that many are not exposed to fresh options at home. 29 schools – approximately 12,000 students – were exposed to WI produce via the salad bars. We can infer that many of those 12,000 students were more likely to eat the produce because it was served on a salad bar.

MMSD Schools and staff: The benefits of Farm to School and serving WI produce at schools extend to school, food service and district staff, who learn about the value of local produce. Over the two-year project, food service staff has come to recognize many of the benefits of local produce and is eager to continue and expand local purchasing.

Other: The project has also benefited local groups, including the FEED Kitchen and the Dane County Farmers Market, who were utilized for produce sourcing and processing for the 2014 summer food program. In addition, other Farm to School entities, such as WI Farm to School, Great Lakes Regional Farm to School, and other school districts have benefited from the lessons learned, recommendations, and relationships built from this project.

V. Lessons Learned

School Food Purchasing

Changing school food purchasing procedures is difficult. Policies and procurement documents require alteration, staff need to change how they operate, the status quo has to shift, and all must be done within the confines of strict USDA and district guidelines. We have learned that promotional purchases for one-time events or small-scale purchases (that fall under the small purchase threshold) are easier to orchestrate and more manageable for food service staff. The larger challenge is changing the procurement methods for regular general produce purchases. While we were able to do this for summer procurement (which is a great start, and has laid the groundwork for change), there is still work to do to make changes in the weekly produce purchasing during the academic year.

Summer Food Service Program

We learned that the Summer Food Service Program is a good place to pilot Farm to School efforts. Food Services are less busy during the summer, serving many fewer meals, so there is more time and space for integrating new things. Cafeterias are also more relaxed and students have more time to eat lunch, which allowed for educational cafeteria activities. Additionally, in WI, serving during the summer takes advantage of the seasonally available produce. I would encourage districts that are having trouble with Farm to School during the school year to pilot some efforts over the summer. However, it has not been simple to transfer our summer success to the school year – partially because the Food Service staff is not entirely the same over the summer. Staff members who work only during the academic year did not gain the same experience of and comfort with working with local product as summer staff. It makes it difficult to keep the ball rolling when staff are not consistent.

Regional Food System

The lack of processors in the region who are fresh-cutting local produce continues to be a barrier to local procurement for MMSD. The District's four routine produce vendors either do not currently process local product or are not transparent about what they will have available, making it difficult to plan for in advance (and with school menus, advance planning is

imperative). These difficult systemic regional circumstances are what led to the REAP Farm to School Snack Program years ago – the only way to consistently get local produce into the schools was to process it ourselves. We have succeeded in developing a relationship with the WI Innovation Kitchen, who processed produce for the carrot/kohlrabi pilot and who will be processing for the 2015 summer program. This is certainly a positive option for us moving forward. However, the fact that none of the large-scale produce processors and distributors routinely work with local products remains a large gap in the institutional supply chain for local produce.

Salad bars and procurement

Of 32 MMSD elementary schools 15 have salad bars. The remaining 17 schools serve raw fruit and vegetables in individually-portioned pre-packs. In conceptualizing this project, sourcing produce for the salad bars was thought of as separate from other sourcing. In actuality, MMSD often serves one or more of the same veggies in the pre-packs each day. When piloting local items during this project, it made sense to serve them on both the salad bars and in the pre-packs because the larger quantities drove down price and made the orders more worthwhile for local suppliers. This way, the produce was also reaching the students at the 17 non-salad bar schools. While the salad bars remain a great way to showcase local items, we have found that sourcing for both salad bars and pre-packs at once has a greater impact. For this reason, it makes less sense to focus on purchasing and procurement data for salad bars only and more sense to include data for all local specialty crop purchasing. This is a change in how we were expecting to report on data for this project.

Communication, Promotion, Education

It is critical to pair promotional and educational activities with farm to school procurement. In a district the size of MMSD, if individual school site food service staff do not receive information and materials about the local products that have been sent to them to serve, they could easily go through lunch service without passing along any messaging about the food to students. Similarly, if school staff, parents and press are not notified in some way about the local items served at lunch, they will likely not know that anything is different. Food service departments need to see the rewards and benefits of Farm to School to recognize the worth - rewards can come in the form of good press, positive feedback from school staff and parents, and (perhaps most tangible) increased meal participation. Indeed, if parents don't know that a great WI-grown product will be in the lunch, it won't have an impact on participation, no matter how tasty. Communication and outreach efforts are essential - internally to food service staff, to school communities and to media to garner public support. This is a very important role that a community partner can help take on - in our experience there is not much capacity for district staff to take this on. We have seen first-hand how these efforts boomerang positively for school food service and make them eager to do more.

VI. Additional Information

Links to media communications regarding this project:

Launch of Leopold Elementary School Salad Bar: https://leopold.madison.k12.wi.us/food-nutrition-and-reap-food-group-launch-new-garden-bar-leopold-elementary-school

Carrot and Kohlrabi pilot:

http://www.nbc15.com/news/headlines/Madison-schools-serve-healthy-local-food-294919781.html

http://madisoncommons.org/?q=content/reap-and-mmsd-team-up-to-bring-fresh-food-to-school-cafeterias

https://food.madison.k12.wi.us/mmsd-food-nutrition-reap-food-group-offer-fresh-local-carrots-kohlrabi

Photos:

REAP AmeriCorps members introduce students at Kennedy Elementary to their new salad bar:

Salad bar assemblies at Leopold Elementary:

Students enjoy local veggies in the 2014 Summer Food Service Program:

VII. Contact Info

Miriam Grunes
REAP Food Group
306 E. Wilson St. Suite 2E
Madison, WI 53703
608-310-7836
miriamg@reapfoodgroup.org

18) Increasing the resiliency and stability of Wisconsin fresh fruit and vegetable sales through legal education and legal services (FY13-018)

Report Date: July 2, 2014

I. Project Summary

A. At present, Wisconsin's grocery industry, produce wholesalers, food service institutions, farmers, and consumers are localizing the food system for several reasons. Buyers want to meet consumer demand. Consumers are interested in the significant economic impact specialty crop buyers may have by shifting purchases locally. Advocacy groups point out that fresh fruit and vegetable consumption improves public health outcomes. In turn, farmers are attracted to the potential for increased profitability by marketing specialty crops locally where they may receive a better price and enhanced control over the relationship. The movement stands to be a win-win-win for consumers, farmers, and buyers.

Yet, despite the apparent advantages, these relationships may not fulfill their promise. Many farmers and specialty crop buyers do not understand the basic outlines of produce contract law, sales obligations, and food safety regulations. At the same time, sales are increasing. As a result, the risks of an expensive contractual misunderstanding or a food safety incident grow. Both food industry and farmers are at risk. Without legal education we create tenuous economic growth, rather than the secure, vibrant local food economy buyers, farmers, and advocates are working to achieve.

This project addressed these risks so they don't erode growth potential. After participating in this project, farmers and their grocery, wholesale or institutional buyers understand how to manage contracts and food safety liability effectively. Educational resources instruct farmers and buyers in the range of legal obligations attendant to a contract to buy or sell fresh produce. A subsequent webinar provided an opportunity for interactive legal education and for farmers to learn about contract law and food safety liability from other producers.

*All work conducted for this project was directed for and presented to specialty crop growers. While other farmers could benefit from the materials created via postings to websites, none were intentionally served by this project

B. N/A

II. Project Approach

To achieve the project goals and outcomes, Farm Commons hosted webinars and developed print materials. We hosted one webinar on Food Safety Regulations and Liability and a second webinar on Selling Products to Larger Buyers. As for print resources, we developed a "Writing a Simple Sales Agreement" guide and a "Farmers' Guide to Reducing the Legal Risks of a Food

Safety Incident." We also developed two supplements to the sales agreement guide: 1) a flowchart to guide farmers in determining if the federal Perishable Agricultural Commodities Act applies to their farm operation and 2) a model sales contract.

To deliver the webinars, we first set up a registration program, together with an evaluation program to get feedback from attendees. We then researched, wrote and delivered the webinars. After that, we did detailed follow up with several farmers who had questions or wanted additional support in understanding the webinar.

To develop the print resources, we performed detailed legal research, drafted the documents, and had the documents reviewed by a farmer and attorney. After editing the resources based on feedback, we issued final versions. Then, we did outreach on the resources, letting many Wisconsin farmers and farm organizations know about them.

Farm Commons was the only partner on the project and the significant accomplishments are discussed in the next section. The project did not have any unusual developments.

III. Goals and Outcomes Achieved

A. 335 individuals attended the two webinars.
On average, 88% of attendees met our specific learning objectives after attending the webinar. In addition, about half of those attendees did not already know the learning objectives before attending.

96% of the farmers attending our webinars made a change to their business by adopting a specific legal best practice. The single farmer that did not make a change indicated that he was already following all our recommended practices. 40% of farmers planned to make more than one change in adopting our recommendations. (Our survey sample size was statistically significant at 44 respondents for 335 attendees.)

We distributed at least 160 copies of the print resources, and we continue to distribute more each day. We were only able to track online distribution from the end of May, and so we do not know how many resources were downloaded between February and May. We expect it is at least double the number after May, or about 320.

B. The following are the goals that were established in the grant proposal:
1.125 Farmers/Buyers will increase their knowledge of the following: basic contract law: creating, fulfilling, and modifying a contract; food safety liability; and risk management overall. This will be measured by two surveys. One will be issued to all webinar registrants before the event and one after the event. The survey will contain quiz-style questions that assess actual knowledge rather than self-ranked improvement.

2. 100 Farmers/Buyers will understand the new FSMA rules and how they impact their individual operation, including strategies to manage growth within the 500K threshold. This will be measured by two surveys. One will be issued to all workshop/webinar registrants before the

event and one after the event. The survey will contain quiz-style questions that assess actual knowledge rather than self-ranked improvement.

3. 20 Farmers/Buyers will draft and implement written contracts. This will be measured by two surveys. One will be issued to all workshop/webinar registrants before the event and one two months after the event. The survey will ask whether the farmer uses specific business practices.

4. 3 farmers will convert to a business entity. One will be issued to all workshop/webinar registrants before the event and one two months after the event. The survey will ask whether the farmer uses specific business practices.

5. 100 farmers will understand basic insurance policies. This will be measured by two surveys. One will be issued to all webinar registrants before the event and one after the event. The survey will contain quiz-style questions that assess actual knowledge rather than self-ranked improvement.

The following is a comparison of how our accomplishments compared with our proposal

1. 113 farmers improved their knowledge on basic specialty crop contract principles, including how indemnification clauses work, the legal importance of written documentation, the legal significance of availability sheets, the legal consequences of not delivering product sold, and the availability of small claims court in the event a sale must be enforced.
    a. This is just under our prediction of 125 farmers. However, the key is that we said we'd improve farmers' knowledge and we actually measured if we gave farmers new knowledge. In fact, just under 90 percent of farmers knew the key legal facts after the webinar- or about 140- but about half of them were already aware of the key facts.
2. 142 farmers understand the new FSMA rules will impact farmers, including that new rules will affect farmers who sell specialty crops to producers and farmers who pack and distribute other farmers' specialty crops.
    a. This is well over our prediction of 100 farmers knowing the impact of the proposed FSMA rules.
3. 112 farmers implemented written contracts and changed their sales availability, invoicing, and payment paperwork
    a. 112 is far over our proposed 20 farmers implementing written contracts.
4. Farmers made many other changes to their business as a result of our webinar. Here are the changes made, by percentage of those attending:
    a. 78% created a paper trail for food safety procedures or communications with agents/officials.
    b. 70% created or modify availability/sell sheets, invoices, or other sales documentation
    c. 63% created new or different procedures for sales
    d. 57% investigated state or federal regulations in detail
    e. 55% modified communication techniques with buyers
    f. 55% created or modify a sales contract.
    g. 50% Looked into or install a tracking system for farm products.

h. 42% examined sales agreements or contracts with buyers.
i. 21% purchased a new or different insurance policy

5. 160 farmers understood the importance of a commercial insurance policy, as compared to only a farm liability policy in terms of protection from food safety incidences.

IV. Beneficiaries

This project was valuable for the specialty crop distributors and food hubs in Wisconsin. We had many food hub coordinators and distributors attend the webinar. They are very interested in understanding how food safety and sales affect their operations as aggregators. The impact of the FSMA is especially relevant to this group of business managers.

The project also benefitted insurance providers as many farmers learned that their current, existing insurance policies may not be broad enough to cover emerging risks from food safety and contract sales. Farmers decided to purchase more or broader insurance policies after attending the webinar.

The project also reached farm-to-school programs as both are very concerned with food safety and with larger-volume and contract sales. Many farm-to-school advocates attended, allowing them to better relay information to farmers and to administrators.

As for the economic impact of the project, the following are the goals projected for the project application:

1. 100 farmers and 15 buyers will increase their knowledge of the following: basic contract law including creating, fulfilling, and modifying a contract; advanced contract law and regulations specific to fruit and vegetable sales; food safety liability; and overall risk management strategies. We estimate farmer participants will 1) either save at least $2000 each in insurance costs, legal fees avoided, and fines avoided, or 2) receive at least $2000 from payments received sooner and sales volumes increased. Buyers and farmers will be able to craft solid contracts with more confidence, leading to increased produce sales approximating $5,000. Total: $230,500

2. 100 Farmers/Buyers will understand the new FSMA rules and how they impact their individual operation, including strategies to manage growth within the $500,000 threshold. We estimate participants will save or receive about $400 each as a result either because of a marketing advantage gained in achieving compliance faster or legal fees saved. Total: $40,000. We believe we met this goal

3. 20 Farmers/Buyers will negotiate and implement written purchasing contracts (including terms on order forms or invoices) with each other. We estimate that this will protect 5% of existing sales of participants that would otherwise be lost to contract breach. Assuming our 20 farmers and buyers will have sales totaling at least $1 million, farmers receive about $50,000 that otherwise would have been lost. Buyers receive marketing benefits from being able to supply local product to customers. We believe we met this goal

4. 20 Farmers will purchase appropriate insurance to address personal liability, product liability or food safety incidents. We estimate this action will result in increased coverage for at least $2 million in assets. In addition, securing proper insurance for a food safety incident, with an accompanying food safety plan, will protect the entire farm from loss if an incident occurs. These values are too speculative to make here, but are still very important to note.

Long term impact: The long-term effect of this project will be greater. Buyer/seller relationships strengthened here will continue to increase sales over time. The educational resources developed will be useful for years to come Also, training the local food community in legal knowledge will return on the investment as farmers and buyers talk with colleagues and begin to create institutional knowledge.

We accomplished each of the objectives above, and we believe our estimate of economic impact is sound. However, considering the nature of risk reduction, we cannot actually show that reduced risk has saved money from misunderstandings or accidents that would otherwise have materialized. Considering the time frame of the project, we can't yet verify that changes made this spring have resulted in increased sales this growing season.

V. Lessons Learned

We had huge success in motivating farmers to adopt legal best practices. It's hard to get just a small percentage of farmers to change their ways, let alone 96% of them. This was surprising and likely the result of offering very concrete, specific means of reducing legal risk and increasing specialty crop sales. We didn't have any unexpected results, but this was a very small, basic project to educate farmers and implement legal best practices that lead to stronger, more resilient specialty crop sales.

VI. Additional Information

None

VII. Contact Info

Rachel Armstrong
Farm Commons
2934 Milwaukee St #2
Madison, WI 53704
608-616-5319
rachel@farmcommons.org

19) Seasonal Extension and Legal Rights Tools for Minority Growers (FY13-019)

Report Date: July 20, 2016

I. Project Summary

A. This project built off of a 2012 SCBG funded project, Production Tools for Minority Growers, where Wisconsin Department of Agriculture, Trade and Consumer Protection (WI DATCP) and Farley Center worked with Midwest Organic & Sustainable Education Service (MOSES) to provide training for 60 Hmong growers at the MOSES Organic Farming Conference. As a result of that project, MOSES was motivated to bring Hmong growers back to the conference to focus training on hoop house production and legal tools. MOSES was willing to give a group discount rate for the minority growers who attended the conference. In addition, MOSES would waive room charges for special sessions for Hmong speaking participants (the largest majority of minority growers attending) and the registration fees for 4 Hmong guides and 2 Hmong interpreters. DATCP collaborated with the Farley Center again to bring 80 Hmong minority growers to the trainings.

Planning with the Farley Center, WI DATCP, and MOSES resulted in two training sessions that were conducted in Hmong language and taught by Hmong growers and Hmong educators. One training session focused on how to construct a hoop house or high tunnel, where to apply for cost share grants and how to select the materials and site selection for a hoop house. Another training session focused on farm legal matters. This training walked through the importance of a written lease agreement and other legal rights important for farm operations. In addition, simultaneous interpretation was provided for at least 3 workshops that are specific to fresh market growers. Last, there was a special networking session for these participants in the evening, to encourage farmers to share what they had learned in their sessions and how they will implement them, as well as other production techniques and tips from personal experience. Participants evaluated their experiences and identified new lesson learned that they plan to implement into their fresh market operation.

B. This project built off of a 2012 SCBG funded project, Production Tools for Minority Growers, where WI DATCP and Farley Center worked with Midwest Organic & Sustainable Education Service (MOSES) to provide training for 60 Hmong growers at the MOSES Organic Farming Conference.

II. Project Approach

This project was a collaborative efforts between Wisconsin Dept. of Agriculture, Trade and Consumer Protection (WI DATCP), Farley Center and MOSES. We met and created a Hmong track for Hmong growers at the 2016 Organic Farming Conference. MOSES secured the rooms, track schedules, conference registrations and transportation to and from the conference. Farley Center arranged and secured presenters, interpreters, interpreter equipment, lodging and others. WI DATCP reached out to minority farmers for pre-registration. We also reach out to Fondy

Food in Milwaukee, WI and Farmers' Legal Action Group in Minnesota for extend invitation and brought their minority farmers for the trainings. With collaborative efforts, we were able to bring 91 participants (85 minority farmers + 4 conference guides + 2 interpreters) to the training sessions in the MOSES Organic Farming Conference.

III. Goals and Outcomes Achieved

A. We hosted an orientation meeting with the group to go over the plan, agenda, and expectations from them at the conference at the La Crosse Hmong Cultural & Community Center on February 25, 2016 - the day before the conference. We also invited a guest from the AgrAbility to talk about their programs and services to the group at the orientation meeting. We conducted a brief evaluation (by showing hands) right after each especial training. We also created an open space at the hotel for them to network and share what they learned to one another after coming back from the conference on the first day (2/26/2016) of conference. After a long day of trainings, they were still excited to share what they had learned and their knowledge on farming with the group. The group exchanged ideas until midnight and then went to rest for the second day of the conference. All of them (100%) showed that they learned at least one new thing from the conference. Below is what captured at the open space discussion.

2016 Hmong Language Program at MOSES Organic Farming Conference
February 25 -27, 2016
La Crosse, WI

What minority farmers learned and feedbacks on Friday night (2/26/2016)

- Seeking for livestock assistances and will come back again next year.
- Learned a new law about organic seasonal crops with no chemical application.
- Learned that none-treated/GMO seeds have more value.
- Learned the risks of un-clean water. A food safety workshop should be provided next time.
- I would like a list of the minority mentors for referral purposes.
- I would like to have access to a distribution center/wholesale markets.
- Learned that there is financial assistance out there, but the farmers need to go and get it.
- Learned about healthier transplant, disease control and fertilizers.
- Learned about their display technics.
- Learned about the drainage system.
- Learned about using Sani date/sanitizer as part of post harvesting.
- Learned about using sanitizer.
- Learned about picking the right time and watch weather for crops harvesting.
- Learned about Avoiding cross-contamination by washing and changing clothes for different work.
- Support good work ethic.
- Support Jack's program and don't lie.
- Washing all tools to avoid cross-contamination.
- I learned that I need to plant deeper to slow germination and avoid early blooming.
- I learned that cutting flowers when they still closed or slightly open is the right time.
- Learned that food safety and teaching workers about washing and cleanliness are very important.
- Cooperation is the key.
- Exchange ideas and knowledge are what I learned the most.
- I learned about food safety—nozzle must not touch the ground to avoid diseases.

B. The following are the goals that were established in the grant proposal

On the grant proposal we stated that we would take 80 Hmong minority fresh market growers to the special training programs on hoop house production and legal rights tools, provided in Hmong language, at the MOSES conference, 98% would indicate that they have learned something they will integrate into their fresh market produce operations. As results, we brought 91participants (85 minority fresh market growers + 4 conference guides who also minority fresh market growers + 2 interpreters) to the 2 special training programs on hoop house production and legal rights tools, provided in Hmong language, and 6 workshop sessions with Hmong interpreters at the MOSES Organic Farming Conference. 100% of minority fresh market growers indicated that they have learned something they would integrate into their fresh market produce operations.

IV. Beneficiaries

The Hmong minority fresh market growers (who participated the special training workshops at the 2016 MOSES Organic Farming Conference in La Crosse, Wisconsin) have learned new knowledge/skills to integrate into their farm operation. After attending the legal rights tools workshop, for example, a Hmong minority fresh market grower call us that he planned to purchase the land that he has been leasing for so many years. With the good experience and benefits from this project, they would put the new knowledge/skills they had learned into good use and come back to learn more in the near future.

V. Lessons Learned

A few minority fresh market growers notified us the day before the event that they could not come to the trainings. It is understandable for a group size this big, but I will encourage them to call us earlier or as soon as they know that they will not be able to attend the event so we have the time for any adjustments. Another issue was check-in at the conference. It was quite challenge to check-in the group at once at the conference registration booth. We will work with conference staff to arrange a different area (not to interfere with the general registration) for the group to check-in next time.

VI. Additional Information

Below are a few pictures of the minority fresh market growers and the special program schedules at the 2016 MOSES Organic Farming Conference.

2016 MOSES Organic Farming Conference Orientation Meeting

2016 MOSES Organic Farming Conference with Hmong interpreters

2016 Hmong Language Program

At the MOSES Organic Farming Conference

February 25-27, 2016 | La Crosse Center | La Crosse, Wisconsin

27TH ANNUAL MOSES ORGANIC FARMING CONFERENCE
Feb. 25–27, 2016
La Crosse, Wis.

FARLEY CENTER
Linda and Gene Farley Center for Peace Justice & Sustainability

DEPARTMENT OF AGRICULTURE, TRADE & CONSUMER PROTECTION • WISCONSIN •

LEGAL ACTION GROUP
FARMERS'

Thursday evening before the conference, an orientation and welcome dinner will be held at the La Crosse Hmong Cultural & Community Center from 6-9 p.m.

The Hmong Language Program offers :

- General farming workshops interpreted into Hmong
- Special presentations in Hmong by Hmong farmers and advocates
- Exhibit Hall with organic farming products and tools for sale and organizations that offer assistance to organic farmers
- Bus provided to shuttle attendees between the hotel and the Conference Center
- Guides available to assist and navigate the MOSES Conference
- Opportunity to network and socialize with other farmers from around the country
- Scholarships available to cover the cost of full conference registration and food (Partial assistance may also be available)

Interested in attending for FREE?

Please contact Jack Chang to register:

Jack.chang@wisconsin.gov or (608)224-5050

Friday, February 26

Workshops interpreted into Hmong:

Quality Produce from Field to Table
Laura Frierichs and Joan Olson
8:15-9:45 a.m. | Room Z

Hardy Perennials for Fabulous Cut Flowers
Carol Larsen
10:30 a.m.-12:00 p.m. | Room D

Growing Healthy Transplants
Randy and George Kohn, Amanda Gevens
3:30-5:00 p.m. | Room D

Workshop presented in Hmong:

Basics for Building a Hoophouse
Cheu Vang
6:00-8:00 p.m. | Room R

Saturday, February 27

Workshops interpreted into Hmong:

Selecting and Adapting Vegetable Seed
Greg Reynolds
8:45-10:15 a.m. | Room H

Cover Crops for Vegetables
Mark Boen
10:30 a.m.-12:00 p.m. | Room C

Grafting for Vegetable Production
Andrew Mefferd
3:30-5:00 p.m. | Room A

Workshop presented in Hmong:

Leasing Farmland
Hli Xyooj and Rachel Armstrong
1:15-2:45 p.m. | Room C

Organized by the Midwest Organic and Sustainable Education Service (MOSES), the Farley Center, the Wisconsin Department of Agriculture and Farmer's Legal Action Group (FLAG).

VII. Contact Info

Jack Chang
DATCP Farm Center
2811 Agriculture Drive
P.O. Box 8911
Madison, WI 53708
608-224-51
jack.chang@wi.gov